FOOD FOR SURVIVAL
AFTER A DISASTER

By the same author:

FOOD FOR BETTER PERFORMANCE

FOOD FOR SURVIVAL

AFTER A DISASTER

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Foreword

HAVING had a number of extremely enjoyable discussions on the subject of Food for Survival with Doctor R. C. Hutchinson, I find the task of writing a short foreword to his excellent book a very pleasant one.

His work on all aspects of food must by now be well known. In this volume he scientifically attacks the problem of providing the best possible means of combining food components in relation to the conservation and maintenance of the proper balance of body fluids.

The author rightly stresses the outstanding importance of water, and discusses in detail the types of food that best conserve body fluids and minimize dehydration. Lack of water, that dreaded accompaniment of shipwrecked sailors and those lost in deserts, is a subject discussed in a masterly manner. How to make sea water drinkable is a matter of great importance and still exercises the best scientific minds.

The art of surviving under disaster conditions will interest everyone. Doctor Hutchinson gives very sound advice on the best means of achieving success under survival conditions. Not the least in importance of the volume is the chapter devoted to packaging, so that survival rations may be kept for the longest possible period in a suitable state for consumption and deterioration and spoilage avoided.

Needless to say, I have a great admiration for the author's work, and wish him every success in his continuous research on the all important subject of survival. Those who read the book will find much of value; at the same time they will find it both pleasant and interesting reading.

L. Lockwood

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Introduction

DISASTERS at sea, in the air and on land are constantly occurring in one part of the world or another. When they occur far from centres of civilization, and there are survivors, food is needed.

There are, of course, some means of transport that are more hazardous than others and the people using such transport are more likely to become involved in a disaster. Nevertheless, anyone travelling long distances away from civilization may be unfortunate enough to become the victim of a disaster, particularly in times of international conflict.

Sea disasters, in which ships sink and large numbers of people are forced to exist under survival conditions, are no longer common peace-time occurrences. Disasters in peace-time are mostly confined to small boats, without daily radio contact with land, that have suffered damage during a storm and may drift helplessly for many days before receiving assistance or reaching shore. During this time, normal supplies of food and water are frequently exhausted, emergency supplies are seldom available and the survivors, even though they may have spent many years at sea, seldom have sufficient knowledge concerning the drinking and conservation of water.

In many parts of the world, there are men flying small two- and three-seater aircraft for the regular delivery of mails, medical supplies and urgently needed stores to people isolated in government forts, observation posts and stations of various kinds. Because these craft frequently fly over wild and formidable country, without the advantage of weather forecasts, emergency landings are not infrequent but, unless they are of political significance, they

receive little, if any, press publicity. Many pilots carry a few cans of food to serve as an emergency ration. This frequently includes bully beef which could be fatal to men faced with the problem of walking long distances with little water.

Lives are also lost by men attempting to walk from motor vehicles that have broken down while crossing large stretches of desert. This is often in spite of the fact that the vehicle was on a well-defined track with the possibility of other vehicles passing within a few days. In many instances, the panic that frequently overcomes a traveller unprepared for such an emergency causes him to start walking without having any knowledge of the importance of body-water economy. Formerly, when camels or other slow-moving means of transport were used, more time was taken in making preparations, greater allowance was made for possible delays and emergencies, and there was less likelihood of a major crisis arising.

The author has been a survivor on both land and sea and has first-hand knowledge of some of the problems that arise. He has examined many types of survival rations specially designed for use at sea or on land, as well as makeshift survival rations put together by airmen flying small craft in remote parts of the world. For a period of several years, he was engaged on the design and testing of survival and other types of rations for use by the three armed forces. With this background he has no hesitation in stating that lives are frequently and needlessly lost because of ignorance regarding what should be eaten or drunk.

Given the necessary storage space, the choice of suitable survival rations would present comparatively few problems but in any ship, aircraft or land transport, equipped with survival rations, accommodation is necessarily very limited and the rations must be designed to be as small in volume and light in weight as possible. Furthermore, they must have a storage life of at least two years under a variety of

adverse conditions. In practice, these problems involve making a number of decisions that depend upon many more considerations than may at first be thought necessary.

In peace-time, ships in distress are usually reached before they sink or, if not, shortly afterwards so that survivors are not likely to be adrift for very long. Small boats are frequently within sight of land although it may take survivors several days to find an opening in a reef or a break in a rugged coastline. Airliners move so rapidly, and may be forced down at such short notice, that a disaster is often followed by a search over a wide area which may go on for days, particularly if the disaster has occurred over dense jungle. When a transport breaks down crossing a desert, or in polar regions, it may be an even longer period before assistance comes to hand, or the survivors reach safety.

The first problem is, therefore, to determine the period for which rations should be provided. This involves an estimate of the length of time before survivors are likely to be rescued or can obtain supplementary foods. The number of survivors likely to be involved, as well as the storage capacity of particular forms of transport and possibly the carrying capacity of survivors, are additional problems that have to be considered before a decision can be made. For survivors at sea, it is generally agreed that, taking all these factors into account, the provision of rations for five days, to cover a period from the second to the sixth day, is a reasonable compromise. It also seems reasonable for survivors on land where longer periods may be involved but, on the other hand, where the chances of obtaining supplementary supplies of fresh food may be greater.

A problem concerning the ration itself is the likely availability of drinking water. As it can seldom be determined beforehand whether or not a survivor will have access to an adequate supply of drinking water, most rations must be based on the assumption that water will not be available and that a small amount must be provided. In addition,

the provision of means for supplementing this amount with water derived from the sea or from inland sources of doubtful purity also needs consideration. Finally, the solid component of the ration must be chosen so that it conserves body water as much as possible and this presents further problems when a ration of high acceptability is the objective.

The need for a high degree of acceptability can hardly be over-emphasized. There is little to be gained by providing a ration that may be ideal scientifically but which survivors will not eat, or only in the last extreme. During periods of stress, many people prefer to go hungry rather than consume food that is unpalatable or with which they are not familiar. In the last extreme, they will eat almost anything but, by this time, there could be considerable impairment of bodily functions. A sudden emergency is not the time to introduce unfamiliar foods or untried novelties. As a means of relieving shock and restoring morale, a hot beverage is most desirable but, in many instances, not practicable.

Climatic conditions can also influence the choice of the solid component of a ration. In polar regions, a large number of calories are required simply for maintaining normal body temperature. Except for desert and sea survival, where the choice of foods that will assist in conserving body water outweighs all other considerations, the provision of calories can greatly assist survivors by conserving body tissue, improving performance and maintaining morale. Hence a decision must be made as to whether the water-conserving effect of a ration is more important than the need to provide a larger number of calories, generally by the inclusion of fat.

It would be most satisfactory to be able to provide a separate ration for every ship, aircraft and land transport according to its routing and region of activity. Unfortunately this is impractical as it would involve a change of ration each time a ship or aircraft moved from one region

to another. A possible alternative would be the provision of an 'all-purpose' ration which could be used under various climatic conditions and which would effect a compromise between the needs of a survivor who can obtain drinking water and one who cannot. This is a more practical approach and would be satisfactory in all cases except a few extremes. Hence, such a ration could more accurately be termed 'multi-purpose' rather than 'all-purpose'.

To be able to understand and appreciate the principles on which the design of survival rations should be based, an elementary knowledge of nutrition is necessary. This is provided in the following chapter. More detailed information may be found in a number of text-books, including one by the author.[1] A knowledge of nutrition would also assist survivors who have the opportunity of supplementing prepared rations with fresh foods. When drinking water is scarce, it would enable them to avoid those foods that are wasteful of body water and that under some circumstances could be very harmful.

It is well known that some people eat, and apparently require, more food than others. Because of this, it is impossible to quote average figures, representing bodily requirements for water or calories, that can be applied with accuracy to all survivors. Throughout the book average figures will be quoted but it is important to realize that they can only be applied with reasonable accuracy to large numbers of people. When applied to individuals, they will nearly always be too high or too low and hence can only be regarded as approximations. Nothing better is practicable.

Although the book has some shortcomings, of which the author is aware, an attempt has been made to base all conclusions on the soundest evidence available to date. There are many points, such as the thirst-provoking properties of certain foods, about which there is a marked difference of opinion. As additional evidence becomes available, modified

[1] *Food for the People of Australia* (Sydney, 1958).

conclusions may be justified but, in peace-time, evidence of any value is extremely difficult to obtain and modifications are likely to be few and infrequent.

The book is designed primarily to assist in providing the most suitable food for use in an emergency during which survival conditions may exist; it may also be of assistance to survivors after a disaster. It should be of particular interest to the armed forces, commercial shipping and airline companies and those planning scientific expeditions and exploration ventures.

I

Food Components and Calories

To be able to understand clearly discussions in subsequent chapters on the value of various foods for survival, it is necessary to have an elementary knowledge of that part of nutrition that concerns the more important components of food and their role in maintaining life for limited periods.

Although the foods normally available for consumption vary widely, they are all composed of at least one of the following components and it is these components that give a substance its right to be called a food.

- Water
- Major Food Solids
  - fats
  - carbohydrates
  - proteins
- Minor Constituents
  - mineral salts
  - vitamins

A few foods, such as drinking water, cooking oils and white sugar contain only one food component, but most contain a mixture of two or more. For adequate nutrition, sufficient of all components, including a large variety of mineral salts and vitamins is essential. These are normally provided by a mixed diet comprising many different foods. For short periods, reserves in the body may be used to provide certain components, as well as energy for warmth and physical activity.

WATER

Water provides no nourishment to the body but transports food to the body cells, carries away waste products

from the cells and is the medium in which all chemical reactions take place.

The body's need for water is second in importance only to its need for air. Nearly two-thirds of the total weight of the body consists of water. Yet it cannot store this material. In fact, the body is continually balancing the amount of water consumed with that excreted. If too much is drunk, the body gets rid of the excess in the urine; if too little is drunk, there is loss of water from the tissues. If allowed to continue, the latter condition would result in dehydration.

The body is provided with water from two sources: that consumed as such, in food and drink, and that formed during the combustion of food.

Water, when consumed as such, never passes straight through the body, nearly 20 per cent being absorbed through the stomach into the blood stream and about 80 per cent through the small intestine. If consumption is in excess of requirements, so that the blood tends to become diluted, enough will be withdrawn by the kidneys to maintain the proper concentration. This automatic control by the kidneys is so sensitive and rapid that, within an hour or less of drinking to excess, the unwanted water will have passed out through the kidneys in the urine.

On the other hand, if consumption is below requirements, the effects of dehydration become apparent with somewhat less rapidity. When the water deficit in the whole body reaches 1 per cent, the blood volume diminishes by about 2 per cent.[1] This means that the blood, which constitutes about 8 per cent of the body's weight, is suffering a greater reduction than the tissues generally. At this level, a person is under a measurable physical disadvantage but can usually recover quickly after the consumption of sufficient water.

[1] E. F. Adolph, in 'Proceedings of the Survival Ration Conference', *Activities Report, 3*, 137 (1951).

A sensation of thirst is not a good indication of water requirements as there is usually an appreciable lag between bodily requirements for water and a feeling of thirst.[2] Hence, for men working in hot environments, water considerably in excess of the amount needed to quench thirst is frequently recommended, even though it may produce a slight feeling of fullness. This water may be consumed as such, or in the form of a suitable beverage. Many people seldom drink plain water but satisfy bodily requirements through the consumption of various beverages.

Solid foods also serve as an important source of water and some may contain more than liquid foods. For instance, tomatoes contain more water than does milk. Many fruits and vegetables contain from 85 to 95 per cent water but lack fluidity because of their woody and fibrous structure which gives them form and rigidity despite their very high water content. A few foods, such as sugar and cooking fats, contain practically no water, but yet may serve as a source of body water for the following reason.

After satisfactory mastication most solid foods are broken down during digestion into simpler chemical units of which they are composed. These units pass through the intestinal lining into the blood stream and are carried to the various body tissues. Here some may be used to build new tissue, or repair that which is worn out; others may be combusted to provide energy. During combustion, which takes place in slow integrated steps, several products are formed, one of which is water. The water resulting from the complete combustion of 10 ounces of fat is almost $10\frac{3}{4}$ ounces, from 10 ounces of carbohydrate, $5\frac{1}{2}$ ounces, and from 10 ounces of protein, about 4 ounces. It has been calculated that, in this way, an ordinary mixed diet may provide $\frac{1}{2}$ to $\frac{3}{4}$ of a pint of water per day.

[2] W. V. Macfarlane, 'Water and Salt Turnover in Cane-cutters Working on the Coastal Sub-tropics of Australia', *Medical Journal of Australia*, 17 August 1957.

Hence, the water available to the body consists of that consumed in liquid and solid foods, and that made available during the combustion of food. This water is lost by the body in several ways. The body loses water continuously as perspiration from the skin and respiratory tract, and intermittently in the urine and faeces. Under some circumstances it may also lose water as sweat, in vomit and from blisters.

The normal loss of water vapour from the skin and respiratory tract is termed the 'insensible loss' because it is a loss that is imperceptible to the senses. In both instances, it takes place by the physical diffusion of water from within the body to the skin surface, or membrane lining the respiratory tract, where it evaporates. Since heat is absorbed during the evaporation of water, this process not only has a cooling effect but assists in getting rid of some of the heat produced during the digestion and combustion of food. The loss is inversely proportional to the relative humidity of the atmosphere and, for the average man, may amount to at least 1½ pints per day. By avoiding deep and rapid breathing, the loss may be kept to a minimum, but in general, it is not possible to reduce it by very much.

The chief function of the kidneys is to remove from the body waste products and any others in excess of bodily requirements. These are removed in the urine. In an average mixed diet, providing about 2 ounces of solid material for daily urinary excretion, a minimum of approximately ¾ to 1 pint of water is required for the solution of this material. When the body has adequate water, the volume of urine is generally much greater than this amount. When the body is short of water, the kidneys conserve it by concentrating the urine to the maximum extent to which they are capable. As a result, the volume of urine that continues to be formed is determined by, and roughly proportional to, the total quantity of soluble material being excreted. Hence, during water shortage,

foods that provide a minimum amount of soluble material for removal are to be greatly preferred.

Faeces consist of the residues of food and other waste materials evacuated by the lower bowel. Their water content is very variable but, in healthy individuals, probably never falls below 50 per cent. Hence on an ordinary mixed diet, about $\frac{1}{8}$ to $\frac{1}{4}$ of a pint of water is excreted in the faeces daily. For a person suffering from diarrhoea, the loss could be very much greater. On the other hand, during water deprivation, there is usually constipation with the passing of small hard stools every few days.

The function of sweat, like that of perspiration, is to cool the body by its evaporation from the surface of the skin. Hence, when either heat production within the body, or the environmental temperature, rises to the point where the heat loss by perspiring is inadequate, the sweat glands become operative. In humid environments, where more sweat is produced than evaporated, sweating rates can be as high as 5 pints per hour. When this occurs, the sweat is simply running off and not accomplishing its purpose of cooling, yet the production increases rather than diminishes. A more usual figure would be about 10 pints per day for a man working in a dry climate where the day temperature rises above about 110°F. or in a humid climate where it rises above about 90°F. At temperatures below about 85°F. depending on the humidity, a man does not sweat unless he is engaged in strenuous physical effort, or unless he is overclothed. Definite figures cannot be given as individual variations are so great.

It may be thought that a man stops sweating as soon as his water content goes down sufficiently. This is not so. A man keeps on sweating, perhaps not quite as rapidly, when he is dehydrated as when he has ample water. Apparently heat dissipation through sweating takes priority over the need to conserve water, and nothing can be done about it. It would kill a man just as quickly to prevent heat dissipa-

tion through the evaporation of body water as it would to stop his supply of drinking water. It can be reduced, however, by suitable ventilation and, for a given temperature, is less the lower the humidity.

Water may also be lost by vomiting. During some forms of sickness all or part of the stomach contents may be ejected through the mouth as vomit. This has a very high water content and can result in considerable loss of body water. When water supplies are insufficient, every effort should be made to prevent unnecessary loss of water due to vomiting. At sea and in the air, this can generally be achieved by taking tablets designed to prevent sickness.[3]

Blisters resulting from severe sunburn, or unaccustomed work, may also cause a small loss of water that could be important to a person suffering from dehydration.

The total water loss of an average man living under temperate conditions is usually estimated at about 3 to 4 pints per day. However, while he is at rest in an equable environment, his insensible loss may amount to as little as 1½ pints, and ¾ of a pint may be lost in the urine. Under these conditions, and allowing ½ a pint for water provided by the combustion of other foodstuffs, his requirement would be about 1¾ pints per day. During a period of water deprivation, however, the amount may be further reduced to about 1½ pints through water within the body becoming available for expenditure. If this amount is not provided, a marked water deficit will result.

A water deficit amounting to 5 per cent of the body's weight may cause discomfort and loss of condition resulting from thirst, impatience, sleeplessness, flushed skin and lack of appetite; a deficit of 10 per cent may cause much greater discomfort and be physically disabling as a result of headache, dizziness, laboured breathing, absence of salivation and inability to walk properly; and one of 20 per cent may result in death, preceded by delirium, swollen tongue, in-

[3] 'Remedies for Seasickness', *Lancet*, 29 August 1953.

ability to swallow, and a numb and shrivelled skin. An inadequate supply of water, therefore, leads to rapid deterioration and, even without other complications, a man without water would be unlikely to survive for more than two weeks but would probably die much sooner.

MAJOR FOOD SOLIDS

The food components that provide the body with energy are fats, carbohydrates and proteins. This, however, is not their only function nor, in the case of proteins, their prime function.

Fats

Fats include solid fats such as meat fat, both on meat and in the form of suet, dripping or lard, milk fat as contained in cheese, cream or butter, and liquid oils derived from animal and vegetable sources. Mineral oils, such as liquid paraffin, and greases, such as vaseline, have no value as foods.

The only difference between solid fats and oils is that due to the temperatures at which they change from one form to the other. Oils have comparatively low melting points and remain liquid at ordinary atmospheric temperatures. They will, if cooled sufficiently, become solid. Peanut and maize oils are liquid at comparatively low temperatures, butter and lard at temperatures slightly above atmospheric and suet and dripping at much higher temperatures.

Fats are of particular importance as a concentrated source of energy, a given weight of fat providing more than twice the energy that would be provided by the same weight of carbohydrate or protein. Fats from animal sources have a slightly higher energy value than fats derived from vegetable sources. In addition to providing energy, fats may also be used to form body fat that can be drawn upon later if more energy is expended than that provided by the food

consumed. When this occurs, there is a reduction in body weight which, within limits, is not necessarily detrimental.

Apart from the changes that accompany mastication in the mouth fats pass unchanged through the mouth and stomach, but in the small intestine they are finely divided until completely emulsified, and then broken down into their constituent parts. In this state they are absorbed into the body where they recombine and are carried away by the blood stream. Fats tend to delay the passage of food through the stomach so that a meal with a high fat content gives a more prolonged feeling of satisfaction than a meal in which the amount of fat is low.

There appears to be no precise physiological requirement for fat as such although there is evidence that it has a regulatory effect on the final breakdown of protein.[4] When fat constitutes 30 per cent of the diet, the urinary excretion of the end-products from the breakdown of protein is less than when fat constitutes 10 or 20 per cent of the diet. On the other hand, as the fat content increases, so does the urinary excretion of products of incomplete fat combustion. These products, which are strongly acid, become abnormally high during periods of starvation when the body is deriving the greater part of its energy from body fat; they are further increased by hard work.

Hence, although fat is of practical importance in providing energy without excessive bulk, very high and very low levels of consumption should be avoided, unless a special diet is needed to meet a particular requirement.

Carbohydrates

Carbohydrates are food components that provide the body with considerable amounts of energy and, under certain circumstances, may be converted into body fat. There are two important groups of carbohydrates—sugars

[4] C. Hoover and P. Swanson, 'Role of Fat in Protein Metabolism', *Federation Proceedings*, 9, 362 (1950).

and starch—although, when the carbohydrate contents of foods are compared, it is customary to consider the total carbohydrate available to the body rather than the different amounts of sugar and starch.

Sugars, the simplest of the carbohydrates, are all sweet and soluble in water. Sweetness is pleasant to the taste but of no nutritional importance. The simplest sugar, and that which occurs naturally in the blood of living animals, is glucose. It also occurs in some natural foods and food preparations and is used in tablet form by athletes. The most common sugar is cane or beet sugar which is familiar as common household sugar.

Starch, which consists of glucose units chemically combined, is the form in which the largest proportion of carbohydrate occurs in human food. It comprises more than half the solid material in cereal grains and potatoes. It is enclosed within granules which, in the raw state, cannot easily be digested and it is for this reason that such foods as flour and potatoes are heated in water before being consumed. This causes the granules to swell, burst and release their contents.

During mastication, starch and sugars are partly broken down by saliva in the mouth, then pass through the stomach where further digestion occurs, and are completely split into simple sugars in the small intestine. From here they are absorbed into the blood stream and may be used for the production of energy or converted into 'animal starch' and stored in the liver. If the liver already contains a large amount, some may be converted to fat and deposited in the tissues.

The tissues of the body constantly require and use carbohydrate under all conditions. It is the principal primary source of immediate energy for muscular exercise, and for other purposes, and a temporary fall in the amount of sugar in the blood, below a certain critical level, may produce serious disability. During periods of food shortage,

when insufficient carbohydrate is available in the diet, the body may convert body protein to meet the deficiency. On the other hand, comparatively small amounts of carbohydrate can spare or save body protein,[5] and there is evidence that protein utilization is favourably affected by the presence of carbohydrate at the same meal.

Fat utilization is also affected by insufficient carbohydrate. A common symptom of starvation is the presence of comparatively large amounts of organic acids and related bodies in the urine due to the incomplete breakdown of body fat. These substances, apart from causing a further loss of body water in the urine, can be detrimental because of their comparatively high acidity. The consumption of small amounts of glucose has been found to promote the orderly breakdown of fat and reduce the presence of organic acids and related bodies in the urine.

Proteins

Proteins may be of animal or plant origin. The muscular tissue, or lean meat, in the bodies of animals contains animal proteins which are also found in milk, cheese and eggs. Plant proteins are found in all foods of vegetable origin but particularly seeds such as cereal grains, beans, peas and nuts. Few foods consist of protein only, most proteins are found to be associated with a considerable amount of fat or carbohydrate. Exceptions are egg white, which is a pure protein in solution in water, and gelatine prepared from gristle, hoofs and horns.

Proteins are needed for growth, repair and maintenance of tissue and, for these purposes, no other food can replace them. Under normal circumstances, the amount and kinds of protein consumed will not exactly balance requirements for growth, repair and maintenance and there is usually some to spare. This excess, which cannot be stored in the

[5] G. R. Hervey and R. A. McCance, 'The Provisioning of Expeditions in the Field', *Proceedings of the Nutrition Society*, 13, 41 (1954).

body to any appreciable extent, may be converted to fat, or used immediately for the production of energy, although it is not as useful as carbohydrate for this purpose.

The protein structure of the human body is similar to, although not identical with, that of animals, but different to that of plants. Hence, if the proteins in the diet are from animal sources, less will be needed for the growth, repair and maintenance of tissue than if they are from plant sources, the difference between human and animal protein being less than that between human and plant. Hence, when the protein intake is restricted, and below bodily requirements, it is advantageous to provide animal rather than plant protein.

Apart from mechanical changes resulting from mastication, proteins pass through the mouth unchanged. They are partly broken down during digestion in the stomach, the process being continued in the small intestine where absorption into the blood stream takes place. During their final combustion in the body, ammonia is formed as one of the end-products; this is converted in the liver to urea in which form it is finally eliminated in the urine. Urea constitutes about half the solid material excreted in urine, the amount excreted by a man on an average mixed diet being over 1 ounce per day. For the disposal of urea the urine must have sufficient volume and, when water supplies are inadequate, this results in the withdrawal of body water.

During periods of insufficient food, the amount of urea in the urine may be greater than that which could be derived from the protein in this food. Even if the food contained no protein, urea would still be excreted. This would result from the breakdown of body protein. If a person has no food at all, urea excretion would continue at a minimal level as long as the body's energy reserves hold out. Finally, when body protein is called upon to provide energy, urea excretion would rapidly increase and,

when the body has supplied as much protein as possible, gradually decrease, until death finally occurs.

The breakdown of body protein during starvation can be reduced by the ingestion of comparatively small amounts of carbohydrate or fat.[6]

MINOR CONSTITUENTS

The minor constituents of food consist of a large number of mineral salts and vitamins.

Mineral Salts

In addition to their importance in building bones and teeth, mineral salts are necessary as constituents of body cells, and to give body fluids the composition and stability essential for life. The body contains nineteen major mineral salts and a number of others that are needed in smaller amounts for more specific purposes. Only common salt, belonging to the former group, will be discussed here.

All body fluids contain about 0·9 per cent salt and it is essential for life that this amount be accurately maintained. Salt can be lost from the body in two ways—in the urine and in sweat. The amount of salt lost in the urine is regulated by the kidneys, but there is no similar means of controlling the amount lost in sweat. If too much salt is consumed, the excess is normally passed out in the urine. This requires extra water and it is for this reason that a salty meal makes a person thirsty. If too little salt is consumed, which frequently occurs during periods of sweating, the reserves in the body are depleted, the amount excreted is reduced and muscular cramp may result. If taken without a sufficient supply of water, salt can be very deleterious. It not only leads to intense thirst and bodily dehydration, but may eventually result in a condition known as 'salt poisoning'. Salt and water are, therefore, very closely related.

[6] G. R. Hervey and R. A. McCance, op. cit.

Under temperate conditions, the amount of salt needed daily by the average man is less than $\frac{1}{4}$ of an ounce. In the tropics, a sedentary man may need $\frac{1}{2}$ an ounce, whereas a man employed on hard physical work for eight hours a day may need almost 1 ounce. During the first two or three weeks of acclimatization in the tropics, requirements may be in excess of the above amounts. Nevertheless, when proper meals are consumed, the salt used in cooking, and as a condiment, is usually more than sufficient to meet average requirements under most temperate and tropical conditions. In exceptional circumstances, it may be necessary to supplement the dietary intake with salt tablets or saline water. Both methods are open to criticism, the former because it frequently causes a feeling of nausea, and the latter because it decreases the potability of water and may discourage the drinking of adequate amounts.

Vitamins

Vitamins are substances, necessary for the regulation of body processes, that occur in very minute amounts in a great variety of foods. The more important number about sixteen and are divided into two groups, the fat-soluble and water-soluble. The body can store large amounts of fat-soluble vitamins but comparatively small amounts of water-soluble. Only the vitamin B group of water-soluble vitamins and vitamin C, which is also water-soluble, will be discussed here.

The vitamins in the B group are often, but not always, found together in the same foods. As a group they are important in the chain of processes by means of which a steady and continuous release of energy is obtained from carbohydrate and protein. Insufficient of any one will result in ill health. It has been found that initial symptoms of vitamin deficiency can occur as early as the fifth day of subsistence on a diet deficient in certain vitamins in the B

group. Early symptoms include nervousness, irritability and mental depression.

The vitamin B group is normally provided in sufficient quantity by a mixed diet containing a variety of foods including whole grain cereal products. If the diet is unusually high in carbohydrate, supplementary supplies may be required. These can be provided by including in the diet such foods as edible yeast or certain vegetable extracts, or, under special circumstances, multi-vitamin tablets.

Vitamin C, a deficiency of which will eventually cause scurvy, has several functions in the body. One concerns the formation and maintenance of the inter-cellular cement-like substances of many tissues. Characteristic symptoms of vitamin C deficiency, some of which can occur within a few days, are weakness, spongy gums, loose teeth, swollen, tender joints and haemorrhages in various tissues. Vitamin C is found in varying amounts in most fresh fruits and vegetables, citrus fruits and tomatoes being particularly good sources.

CALORIES

It has already been mentioned that the body derives energy from the slow combustion of fats, carbohydrates and proteins. Hence, the total energy value of a food is the sum of the energies derived from each of these components.

Energy, including body heat which is a particular form of energy, is measured in calories in the same way as height is measured in feet and inches. One ounce of fat can produce about 255 Calories, and one ounce of carbohydrate or protein about 113 Calories.[7] By using these figures, the energy value of any food can be roughly calculated if its proximate composition is known. Because water has no

[7] The caloric content of food is always expressed in large or kilocalories. When used to define a specific number of calories, the term is spelt with a capital C.

caloric value, it is evident that very watery foods are low in calories.

Energy from food is used by the body for the following purposes:

(a) to provide the body with heat and thus maintain body temperature;

(b) to maintain such processes as breathing, blood circulation and muscle tension;

(c) for everyday activities such as standing, sitting, dressing, eating and moving about;

(d) for the performance of occupational work and exercise additional to the above.

The amounts of energy used by different people for each of these purposes depends on several factors. In the first place, it depends on body size, the average number of calories required by a big man being greater than for a small man. Secondly, it depends on a person's age, a young man generally requiring more energy than an older man. Thirdly, it depends on climate, less energy being required in a hot climate than in a cold. If protection from clothing is adequate, however, the difference due to climate would not be great.

During the digestion of all foods, there is a characteristic amount of heat produced. For protein it may average about 25 per cent of the caloric value of the protein ingested, but for fat and carbohydrate it may be only about 5 per cent or less. This heat is not available as energy for work, but merely adds to the heat of the body. In addition energy is liberated in the form of heat during muscular activity, and this also assists in maintaining the temperature of the body, overheating it when muscular activity is strenuous. It is for this reason that people when cold sometimes voluntarily clap their hands and stamp their feet, or involuntarily shiver to keep warm.

In a resting condition without food, about 75 per cent of the body's heat is lost through radiation and conduction,

nearly 25 per cent through the evaporation of moisture from the skin and respiratory tract, and the small remainder in the urine and faeces. In cold weather, if clothing is insufficient, more heat would be lost through radiation and conduction and extra heat required to maintain body temperature. On the other hand, if the weather is warm or the body overclothed, less heat would be lost by these means, and sweat could be produced in an attempt to prevent the body from becoming over-heated.

The amount of energy needed by men of average size for the mere process of keeping alive is almost 70 Calories per hour, or nearly 1,680 Calories per day. This expenditure, which drops slightly during sleep, is merely to maintain life. Every muscular movement not associated with breathing or blood flow requires additional energy. During starvation, when the body is not receiving sufficient energy as food, the energy requirement for merely keeping alive is very much reduced. For instance, it may readily drop to 1,500 Calories or below and, during a prolonged fast, may even drop to 1,000 Calories. This serves as an automatic reduction of the body's daily drain on supplementary sources of energy, such as its own fat.

The amount of work a man can do, for instance in climbing a hill or rowing a boat, can also be measured and expressed in calories. When the amount of work expressed in calories is compared with the energy value of the food consumed, the physical efficiency of the body can be calculated. This is ordinarily about 10 to 25 per cent. Hence, as the body can convert only about 10 to 25 per cent of the calories derived from food into physical work, the remainder is converted into heat and it is for this reason that physical exercise heats the body.

The amounts of energy required for different kinds of physical work per hour would normally fall within the following ranges:[8]

[8] R. C. Hutchinson, *Food for Better Performance* (Melbourne, 1958).

Eating	30- 40 Calories
Climbing	580- 670 ,,
Rowing	190- 610 ,,
Running	480-1,140 ,,
Swimming	240- 600 ,,
Walking	100- 360 ,,

These ranges are based on average figures. Apart from body weight, three important factors may influence expenditure within these ranges. For instance:

(a) increased speed of performance increases energy expenditure;

(b) trained people work with less expenditure of energy than untrained;

(c) wearing heavy clothes in cold climates may increase energy expenditure.

If more than the daily requirement of food is eaten, some will be converted into body fat and, in times of normal living, many people tend to carry some excess fat. If less food is eaten than that required for daily activity, there will be loss of body weight. The body would at first draw upon the small amount of animal starch stored in the liver and, when this has been used, body fat would serve as the principal supplementary source of energy. When most of the body fat has disappeared, body protein would then remain the sole source of energy. Appreciable loss of protein can, however, be prevented if sufficient carbohydrate is consumed to meet energy requirements. The harmful effects of a deficiency in calories would be relatively slight over a period of days but, if the deficiency continues for a long enough period of time, work performance would eventually be seriously impaired.

Hence, it will be seen that a very important function of fats, carbohydrates and proteins is to provide the body with energy. When food supplies are adequate, interest in the energy value of foods is limited because appetite can usually be relied upon to equate the amount of food eaten

to at least the body's energy requirements. When food is in short supply, the paramount importance of conserving calories to the greatest extent possible is obvious.

2

Meeting Requirements for Drinking Water

THE BODY of a man weighing 150 pounds contains approximately 75 pints of water. This quantity is normally maintained by a balance between water intake and water losses. A daily intake of about $2\frac{1}{2}$ pints from food and drink will normally maintain the balance, provided losses from sweat and vomit are almost negligible. If a man is deprived of sufficient water, or loses considerable amounts in sweat or vomit so that his intake is not sufficient to balance his losses, he will at first suffer physical discomfort and loss of efficiency and, if the condition continues, ultimately die.

During a period of 24 hours, a man sitting exposed to the sun in an open boat in the tropics may lose up to 10 pints of water, mostly in the form of sweat. Losing water at this rate, when supplies are limited to 1 or 2 pints per day, could bring about death by dehydration in about 3 days. Physical exertion would increase the loss which could reach 25 pints or more for a man walking about under tropical conditions. This would be almost entirely a sweat loss, the urinary loss being only about $\frac{3}{4}$ of a pint. At this rate, and with only 1 or 2 pints of drinking water, a survivor would be in very poor condition after one day.

There are several ways in which body water can be conserved. In the first place, when water is available, but in insufficient quantities, none should be consumed during the first day unless the sweat loss during this period is excessive. This is most important because, initially, the kidneys may not be conserving water fully and this would ensure that water consumed later on will be used more economically. On subsequent days, the full allowance may be con-

sumed every day, preferably in small amounts at frequent intervals. No economy can be achieved by reducing the consumption of water below that required to cover minimum losses from the skin, respiratory tract and in the urine. The deficiency would be made good simply by the withdrawal of water from the body tissues to their detriment. Furthermore, it would mean that a survivor, who is rescued while he still has some drinking water left, would be in a poorer condition than if he had met minimum bodily requirements from the beginning.[1]

Further conservation of water may be effected by preventing the body from becoming hot. When the amount of heat, absorbed by the body through sitting or moving about in the sun or produced in the body by physical exertion or exercise, reaches a certain level, an involuntary attempt will be made to reduce it by the production of sweat. Sweat, on evaporation from the surface of the skin, has a cooling effect, but the environment must be dry enough to enable evaporation to take place. By this method of cooling the body, considerable amounts of water may be expended as previously indicated. Hence, if there is already a water deficit, sweating would cause it to reach a dangerous level much more rapidly.

In a lifeboat in the tropics, a boat-cover or awning of some kind can often be erected to provide shade over part of the boat. In an inflatable rubber raft, excellent protection from the sun is provided by a tent-cover and full advantage can usually be taken of any breeze by opening the ports, particularly if a sea anchor is available to keep the raft in the direction of the breeze. It is also an advantage if survivors keep their clothing wet with water during the day-time, a simple device for those at sea. By this means the body is kept cool by the evaporation of water from its clothing rather than from its skin. The clothes should be

[1] G. R. Hervey, 'The Physiology of Survival at Sea', *Science News*, No. 38 (1957).

allowed to dry out by sunset as tropical nights can be quite cool. Finally, survivors should lie as quietly as possible during the day, any necessary activity being postponed until the cool of the evening. If all possible precautions are taken, and other conditions favourable, an inactive man at sea may remain alive for as long as two weeks on as little as two pints of water for the entire period.

Sea-sickness could reduce the period. The motion of life-boats, and particularly rafts, may be very unpleasant and sea-sickness can greatly increase the loss of body fluids in the form of vomit. To prevent this, some form of sea-sickness preventative, such as hyoscine, should be included in all lifeboat and raft equipment. It would, of course, be an advantage if survivors could be issued with their allowance of such preventative before leaving their ship or aircraft. Unfortunately, in aircraft in particular, there is seldom sufficient time for this to be done.

In the desert, shade can frequently be found or improvised. If there is a damaged motor vehicle or aircraft resting on soft sand, and it is possible to scoop away some of this sand, shade will not only be provided but the temperature will be found to be several degrees lower at a depth of 2 to 3 feet. Alternatively, it may be easier to drape a tent or parachute over part of the vehicle or aircraft, with openings around the bottom to catch any breeze. These can be closed at night for greater warmth. In this case, ventilation is further improved by having beds raised off the ground. If no shade can be found or improvised, every effort should be made to keep the whole of the body covered during the day with loosely fitting garments to provide the greatest possible cooling effect.

Desert water tables have been prepared by various authorities showing periods of likely survival at various temperatures when different amounts of water are available. The figures in these tables are not in full agreement but they suggest that under high daily temperatures, such as

may exist in a desert, a man with 8 pints of water, resting in the shade at all times, may remain alive for as long as 7 to 8 days; if he travels at night, he may remain alive for 4 to 5 days when he can expect to cover about 30 miles. The table on p. 29 has been prepared by conservatively combining results from two water tables[2] published during or after World War II.

Both on land and at sea, inadequate protection from the sun may cause severe sunburn. Apart from being very painful, the blisters that result can cause further loss of body water and, when water is restricted, reduce the period of survival. At sea, salt water boils are also particularly objectionable for the same reason, and every effort should be made to prevent them.

In cold climates, conditions are altogether different. It is a comparatively simple matter to avoid loss of water through sweating so that protection from cold rather than shade from the sun is the necessary requirement. When exerting himself, a survivor can usually prevent sweating by opening his clothes at the neck, wrists and ankles, and loosening them at the waist. If he is still too hot, some clothing may be removed but it is important to replace any clothing removed as soon as the work is finished, to prevent getting a chill.

Chewing a button or other small object may, for a while, assist in keeping the mouth moist, as the jaw movements increase the salivary flow, but it gives no real benefit during a shortage of water. On the contrary, it may tend to increase the insensible water loss and, during a period of several days, would expend considerable amounts of energy unnecessarily. Furthermore, there is always the possibility that the object may be swallowed, causing further trouble. Likewise smoking is of no benefit but may result in a more uncomfortable dryness of the mouth. On

[2] *Desert Survival* (Air Ministry Pamphlet 225, London, 1952). *Army Air Forces Survival* (AAF Manual 64-0-1, Washington, 1945).

the other hand, for habitual smokers, its value in maintaining morale is most marked.

Desert Water Table

Condition and max. shade temp.	*Total water available per man*	*Approximate survival in days*		*Approx. distance (in miles) that can be covered when travelling*
		Resting in the shade at all times	*Travelling at night, resting in shade by day*	
Hot 100°F. and above	no water	2 – 5½	1 – 3	20
	2 pints	2 – 6	2 – 3½	20
	4 pints	2 – 6½	2 – 3½	25
	8 pints	2½ – 7½	2½ – 4½	30
	20 pints	3½ – 11½	3½ – 6½	40 – 50
Warm 80°F. to 100°F.	no water	5½ – 9½	3 – 7½	20 – 40
	2 pints	6 – 11	3½ – 8	20 – 50
	4 pints	6½ – 12	3½ – 8½	25 – 55
	8 pints	7½ – 14	4½ – 10	30 – 65
	20 pints	11½ – 23	6½ – 14	50 – 90
Cool 80°F. and below	no water	9½ – 11	7½ – 8½	45 – 65
	2 pints	11 – 12	8 – 9	50 – 80
	4 pints	12 – 13	8½ – 10	55 – 110
	8 pints	14 – 16	10½ – 12	65 – 165
	20 pints	23 – 25	14 – 17	90 – 180

For present-day catastrophes in the air, at sea, and on land, it can be reasonably assumed that, if organized assistance is to be made available, it will be forthcoming within a period not exceeding six days. Hence, modern survival rations are generally designed to keep a survivor in reasonable physical condition for this period. There will, of course, be many disasters about which it will not be possible to send out distress signals and, because of this, some survivors will have to live for much longer periods before they can hope to obtain assistance. It is practically impossible to cater for such circumstances except by

making provision for the collection of supplementary supplies after the emergency.

If physical discomfort and loss of condition are to be largely prevented for a period of 6 days, survival rations would have to contain at least 7½ pints of drinking water per person. This would provide 1½ pints per day for each day except the first. This, and the small amount of water produced during the combustion of food in the body, should prevent physical deterioration from becoming very pronounced in the average, non-sweating survivor. After the sixth day, unless supplementary supplies are available, deterioration could rapidly become evident and death could be expected to occur within a further 1 to 2 weeks. If much water is lost as a result of sweat or vomit, marked deterioration would occur before the sixth day.

If insufficient storage space, or some other condition, does not permit a ration of 7½ pints of water per person, then the quantity could be reduced as low as 5 pints, or 1 pint per day for each day from the second to the sixth, but only with a corresponding increase in physical discomfort and loss of condition. If, at this level, the solid component of the ration consists of pure carbohydrate, such as glucose, then the reduction would not be quite as drastic as might appear; nevertheless, 5 pints is regarded as a minimum. With a ration of less than 5 pints, a survivor could be in very poor condition at the end of 6 days, particularly if he has had to physically exert himself with a consequent loss of sweat.

It may frequently happen that, for survivors on land, there is an abundance of drinking water. Under such conditions, survivors would benefit by drinking enough water to keep their thirst quenched at all times. In fact, water considerably in excess of that needed to quench thirst may be even more beneficial providing it does not result in an unpleasant feeling of fullness, restricting easy movement of the body. If it is available, water should be consumed

whenever a man is thirsty, and not between periods of exertion only, or at any particular time of the day. It is a fallacy that water taken during the heat of the day is immediately lost through an increase in the amount of sweat.

PROVISION OF WATER

Water for use as part of a survival ration may be provided in bulk or in small individual containers. The number of occasions on which bulk supplies can be used to advantage is limited and largely confined to lifeboats.

When water is provided in bulk, in breakers or tanks, space may be saved but the water has a comparatively short life and requires frequent replacement. Before replacement, each container has to be scalded to destroy sources of bacterial contamination. Even so, the fresh water is not sterile and deteriorates fairly rapidly, particularly under tropical conditions. It also requires frequent inspection to ensure that it is fit and safe to drink. Chemicals are sometimes added to extend the period during which the water can be safely consumed. If the breaker or tank is damaged, or the water becomes contaminated, there is a risk of losing the total contents which may be the only water available. Furthermore, bulk supplies present the problem of equally dividing the water available, and in giving one or more survivors, who may be moving off separately, the amount to which they are entitled. They present special problems in polar regions when the water freezes.

On the other hand, small amounts of sterile water in hermetically sealed metal cans have a long storage life and are easy to portion out before or during an emergency. The canning of water in hermetically sealed containers has been practised commercially for many years. Some of the earlier products suffered serious quality defects. For instance, due to internal rusting of the cans, the water was frequently brown, depositing a sediment of rust. Also, it

sometimes picked up off-flavours during processing, or from the container. These defects become immediately apparent because of the clear colour and naturally neutral taste of water. They can be avoided if processing is carefully conducted. The process is briefly as follows.

Fresh water, to which a little citric acid is sometimes added, is boiled for at least 5 minutes to remove air bubbles, cooled to a temperature of not less than 190°F. and then poured into cans that are sometimes coated internally with lacquer or wax. If the cans are to be stored on ships, where they will possibly come into contact with salt water, they are coated externally also. The cans are then closed before any appreciable drop in the temperature of the water occurs, and retorted at 240°F. for about 10 minutes. They are then cooled and, after 24 hours, inverted and re-inverted to reduce the corrosive effect of drops of condensed water on the upper inside ends of the cans. Some processors claim that a better product, completely free from internal discoloration, can be produced by filling the cans at not less than 190°F. and omitting the final retorting at 240°F.

Properly canned water has a storage life of at least two years which is largely dependent upon the maintenance of a high vacuum in the cans. Hence, if the cans on board ships are to withstand repeated rough treatment during lifeboat practice, or those on board aircraft repeated ascents to and descents from high altitudes, and still retain a high vacuum so that they will be in first class condition for an emergency, they must be very robust and properly packed in a suitable cushioning material.

Recently, some success has been achieved using plastic polythene flasks for holding water. The flasks have an advantage over metal cans in that they are lighter in weight and can be re-stoppered. To prevent the development of off-flavours, it appears necessary to use polythene in which a small amount of carbon black has been incorporated. Water, of a high degree of purity, after chlorina-

tion, and sometimes after the addition of citric acid, is boiled for 30 minutes and then filled into previously cleansed flasks at 175°F. As the physical properties of the flasks do not permit the water to be further heat processed, the greatest care must be taken to prevent contamination during the filling procedure. It is believed that water flasked in this way has a storage life of at least one year.

If a ration is designed to cover a period of six days, individual containers of water should each hold one-fifth of a person's total allowance. However, the size of the containers will need to be greater than that required to hold exactly this amount in order to provide a small head space for expansion of the water which, under some conditions, may freeze. With every batch of metal cans there should be a can opener that can be used to pierce the top of the can to permit consumption of its contents. It can also be used to remove the top cleanly so that the can is available for other purposes. One or more metal spikes may also be considered necessary. With plastic flasks, a piercing or opening device is unnecessary as the flasks are stoppered.

SUPPLEMENTARY SOURCES OF WATER

In addition to the drinking water supplied as part of the survival ration, it is very desirable that means be provided of supplementing this water with any other that may be obtainable from natural sources, the best natural source being rain.

On land, small amounts of rain may be collected in any suitable container or from the bases of many plants, surfaces of broad leaves, holes in tree trunks and cracks or cavities in rocks. A clean piece of waterproof material of almost any kind is useful for collecting larger amounts, and equipment is available that consists of a plastic sheet with an outlet tube attached to the centre through which water can be drained. This may be suspended in the air

with a clean weight in the centre, or spread over a depression in the ground.

Dew can provide smaller amounts of drinking water. It may sometimes be collected by scooping a small hole in the ground, covering it with a piece of waterproof material and then filling it with stones. It may also form on the cold outer part of motor vehicles and aircraft where it can be mopped up with a cloth. The water in the radiator of a motor car can also be drunk but it should first be strained through cloth to remove oil and rusty sediment. The water in batteries should not be consumed—apart from its high acidity, it may contain lead in toxic amounts.

Water can sometimes be obtained from rivers and creeks and it is safe to drink unless it has been contaminated closer to its source by refuse from an adjoining settlement. The appearance of the water is no guide to its purity. Heavily contaminated waters frequently appear crystal clear. Water may also be obtained from swamps and water-holes by squeezing wet mud in a cloth or digging for it. On sandy beaches a hole may be dug just above high water mark and digging stopped as soon as water appears. In desert country a hole may be dug at the lowest point of the inside bend of a dry river bed, or wherever the sand appears to be damp.

Rain water and dew, collected in clean containers, are safe to drink but water collected from wells, ponds, swamps and sometimes creeks and rivers may be contaminated with disease-producing organisms. Hence, such water should be boiled or sterilized before it is consumed. Boiling may not always be practicable and under these circumstances water sterilizing tablets are of value. These usually consist of two different kinds of tablets, one of which is used for sterilizing the water and the other for removing the unpleasant taste resulting from the sterilization. Single tablets that serve both purposes are also available.

There are several kinds of sterilizing tablets in common

use. They are usually white and of such a size that one tablet is sufficient to sterilize a specified amount of water, frequently 1 pint. One tablet is placed in a water-bottle or other container, the correct amount of water added, and the whole vigorously shaken until the tablet has dissolved. The water is then allowed to stand for about 30 minutes. Next there is added a taste removing tablet that is usually blue. The whole is again vigorously shaken until the tablet has dissolved. The water is then fit to drink. Both the sterilizing and de-tasting tablets[3] should be sufficiently hard to withstand carriage on a person without crumbling. At the same time, such hardness should not unduly interfere with their solubility in water. The tablets can be prevented from rattling, and hence breaking, by placing a plug of cotton wool in each container. They should be kept dry, and the container airtight, when they could have a life of at least 2 years.

If water cannot be boiled and sterilizing tablets are not available, fairly satisfactory results can be obtained by adding 2 or 3 drops of iodine or 1 to 2 small Condy's crystals to about 1 quart of water, shaking vigorously and allowing the water to stand for about 30 minutes before drinking. The fact that some waters have a brown or muddy colour does not mean that they are unfit for consumption although it may be wise to drink sparingly for the first day or two. If the water has a strong salty taste, resembling that of sea water, it should be consumed with caution.

At sea, the tent covers on inflatable liferafts frequently have incorporated in them a roof-drainage device for collecting rain. In a lifeboat, a boat-cover or sail can sometimes be spread out and cupped sufficiently to catch rain without contamination by sea spray. Sails that have been dyed should be used with caution as the dye may be poisonous and soluble in water. In any case, the first water

[3] The active principle in sterilizing tablets may be chloramine-T or halazone and in de-tasting tablets sodium thiosulphate.

collected may have to be discarded because of salt from dried salt spray remaining in the fabric. If the water collected is more than sufficient for immediate requirements, the excess can be stored in tanks, empty cans or other available containers. To prevent evaporation, spillage and contamination by sea spray, the water should be placed in containers that have tops or can be covered in some way.

Dew may sometimes form on rafts and boats, particularly when there are cold metal surfaces. This can be mopped up with a cloth and squeezed into a container. Movable surfaces should be arranged so that any dew will not run off and be lost under the bottom boards. It has been recorded[4] that almost one pint of water was collected in an open rubber raft as the result of one night's deposition.

It has been claimed that if large fish can be caught and a long deep slit cut in their sides, the opening will soon fill with a drinkable fluid. It has also been claimed that drinking water can be squeezed from fish. These statements need confirmation. They certainly are not true for some small coastal fish from which it is most difficult to obtain appreciable amounts of water using the above methods or with equipment likely to be available to survivors at sea. Some water, however, may be obtained by chewing the flesh and spitting out the residue.

In very cold climates, both on land and at sea, the collection of drinking water presents different problems. It is extremely difficult to obtain adequate amounts of water from snow or ice and subsequently maintain the water in a fluid state when the atmospheric temperature is many degrees below zero. Under such circumstances, the danger of dehydration can become just as real as when there is no water available. If water is to be obtained by melting snow or ice, some equipment is necessary, otherwise attempts will

[4] See A. Bombard, *The Bombard Story* (London, 1955).

be made to melt it in the mouth at the expense of body heat. This equipment should include a few waterproof matches, some solid fuel or canned heat, and a metal can which could be one of those used to provide the water or solid portion of the ration.

Unless contaminated with sea spray, water from icebergs is fresh and may be drunk. Care is necessary in approaching icebergs as they sometimes fall to pieces and can be dangerous. The water from pools at the edges of ice floes will probably be fresh and fit to drink. Unless it has begun to deteriorate or has sea water splashed on it, sea-ice can be used as a source of drinking water. It may be bluish or milky grey in colour, has rounded corners, splinters easily and is free from salt.

Two devices have been designed for making sea water drinkable. They differ in principle, one being a plastic solar still[5] and the other a desalting kit.[6] Both have merit under particular circumstances and each will be briefly described.

With the exception of a specially treated black evaporator bag, the latest solar stills are made entirely of plastic. When folded, one will fit into a can smaller than that normally required to hold one day's allowance of water. When inflated ready for use, the still forms a sphere approximately 24 inches in diameter which floats on the sea. Its operation is quite simple.

The still is first inflated when the black evaporator bag becomes suspended within the resulting sphere to which it is attached at many points. It thus forms a many-sided figure which presents a number of facets to the sun. Sea water is then poured through the neck of the still filling a ballast chamber at the base. This holds the still in an upright position. When the ballast chamber is full, the water

[5] See 'After "Ditching" What?', *Bakelite Review*, July 1951.

[6] See 'Drinking Water from Sea Water by a Chemical Method', *Water and Water Engineering*, October 1945.

backs up to fill a sea-water reservoir at the top of the still from which it flows through a restricted orifice on to the evaporator bag.

The sun's rays pass through the outer plastic surface of the still on to the evaporator bag which absorbs them, thus becoming warm. Since the bag has little opportunity to cool (the plastic sphere protects it from the outside air)

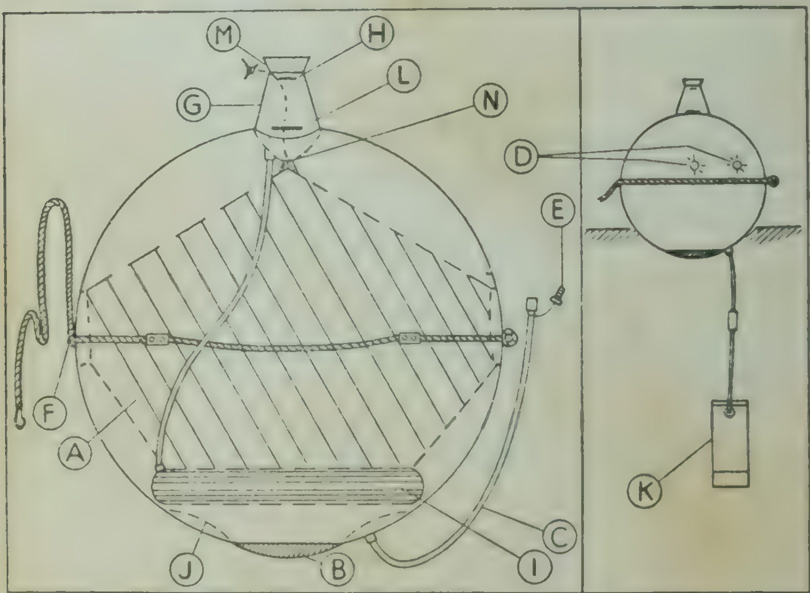

FIG. 1. Diagram of a Solar Still

(A) *Evaporator Bag.* (B) *Drain cloth.* (C) *Freshwater tube.* (D) *Circles.* (E) *Plug.* (F) *Tow/Handling line.* (G) *Reservoir.* (H) *Full mark.* (I) *Ballast chamber.* (J) *Freshwater trap.* (K) *Freshwater container.* (L) *Line* (M) *String.* (N) *Water feed.*

evaporation occurs. During evaporation, water vapour rises leaving a sediment of salt on the bag. When the vapour reaches the outer plastic surface, which is kept cool by the action of the outside water and air, it condenses, collecting in a fresh water trap from which it is drained off through a plastic tube. A diagram of a still is given in Figure 1.

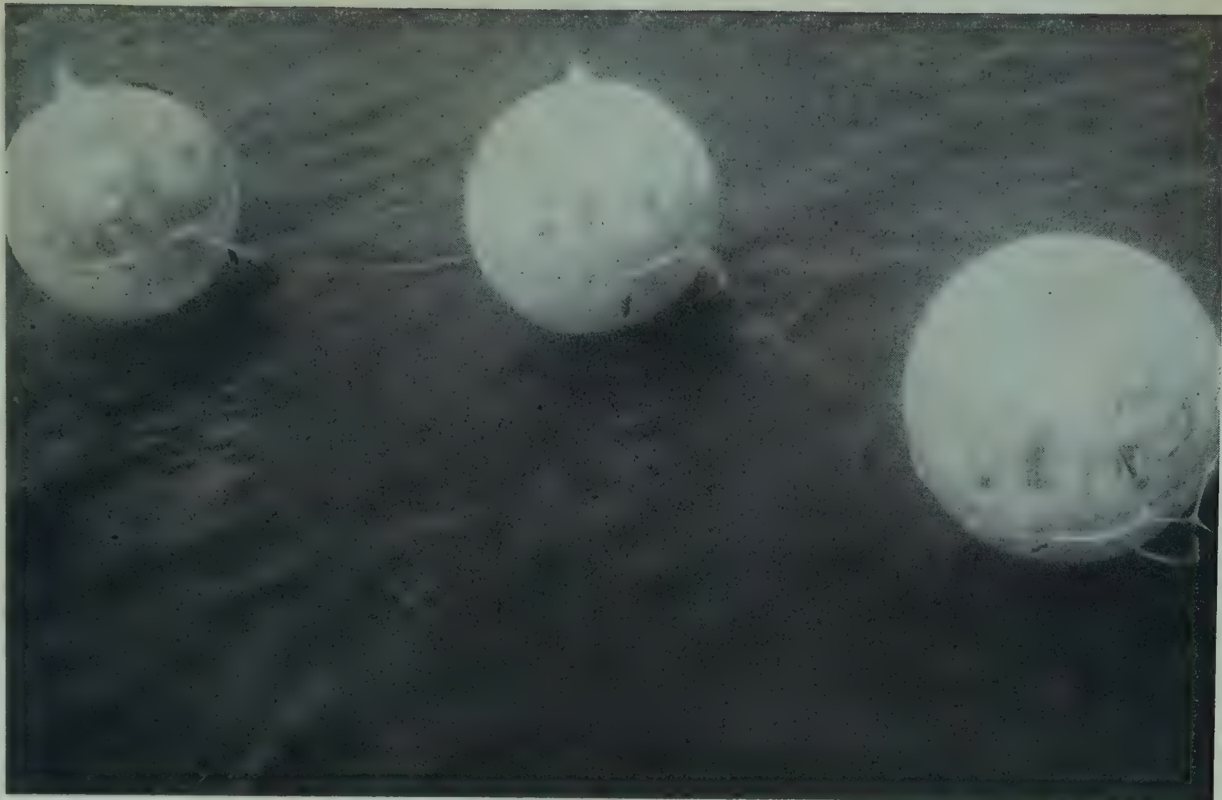

Plate 1. Solar Stills

Stills in operation after being inflated with air and charged with sea water

PLATE 2. Desalting Kit

After it has been removed from its container and ready for use

The amount of drinking water that a still of this kind can produce depends to a large extent on the amount of sunlight available. With plenty of sunlight it can produce over 2 pints per day. Even without bright sunshine, and with a considerable amount of cloud, the still may produce some water, owing largely to the action of infra-red rays. However, there are many conditions under which the amount of drinking water produced will be negligible and it is for this reason that solar stills are provided only as a means of supplementing the small amount of drinking water contained in survival rations. For this purpose, they have a real value.

Desalting kits are available in several sizes. One size in common use consists of a flexible purifying bag made of rubberized fabric, nine chemical charges that are enclosed in a waterproof storage bag to keep them dry during storage and during the use of the apparatus, and a plastic drinking box into which the rest of the equipment is packed. Each chemical charge will produce half a pint of drinking water from sea water so that this particular size will produce a total of 4½ pints of drinking water. The ratio of the amount of water provided by the desalting kit to that which can be carried in cans occupying the same space is 6:1. The desalting kit, therefore, shows considerable economy in packing space.

To produce drinking water, sea water and a chemical charge are added to the flexible bag of rubberized fabric which is fitted with a permanent filter cloth. The whole is then thoroughly shaken and the water filtered by squeezing the flexible bag so that the water passes through the filter cloth leaving all suspended matter behind. The drinking water is squeezed into the drinking box. It is free from salt and has a clear, bright appearance that results from the incorporation of a small amount of carbon in the charges.

It will be apparent that desalting kits are more reliable than solar stills and, during a voyage in 1951 across the

Atlantic Ocean,[7] the only water used by the crew of a 5-ton sailing boat was desalted sea water. Unfortunately, the chemical charges used in desalting kits are relatively expensive. This appears to be the chief objection to their use and, if the price could be reduced, they would probably find greater acceptance as a substitute for bulk and canned water on board ships and in aircraft. In the meantime, their use is restricted to some survival packs.

DRINKING SEA WATER, URINE AND SWEAT

When a survivor has insufficient drinking water, and is in a state of dehydration, his condition is made worse by the drinking of sea water.[8]

There are popular accounts of men having drunk sea water for various periods,[9] but no records of how much better these men would have been if they had not consumed sea water, nor to what extent their judgment was impaired by the drinking of sea water. Small amounts of sea water in the form of spray on the lips and fingers will almost certainly be consumed, but this is unavoidable and comparatively insignificant. *It is possible to drink sea water, but never to advantage.*

Salt in excess of bodily requirements would be mostly excreted in the urine and, as the maximum concentration of salt in the urine is less than that in sea water, the body is robbed of water in the interest of excreting salt. The position is the same whether sea water is consumed as such or mixed with fresh water. The harmful effect appears to be due more to the increased concentration of body fluids, following the withdrawal of water from the body, than to their actual reduction in volume. The salt concentration

[7] The Permutit Company Ltd, London, *Technical Publication*, no. P77.

[8] R. A. McCance and others, *The Hazards to Men in Ships Lost at sea, 1940-44* (H.M.S.O., London, 1956).

[9] A. Bombard, op. cit.

in body fluids approximates a 1 per cent solution, whereas human urine never contains more than about $2\frac{1}{4}$ per cent, and sea water about $3\frac{1}{2}$ per cent. From this it will be seen that a concentration of body fluids would occur whether the salt is excreted in the urine or not. If it were not excreted, its presence in the body fluids would directly increase the concentration and, when it is excreted, the concentration of body fluids is increased because of the water removed to carry away the salt.

During water depletion, the urine is concentrated to the greatest possible extent. Hence, even if the excretion of salt in the urine is comparatively low, salt from the drinking of quite small amounts of sea water cannot be added without an increase in the volume of the urine. This increase in volume will be that necessary to maintain an approximately $2\frac{1}{4}$ per cent solution of salt. This means roughly that for every pint of sea water drunk, an additional half pint of body water is expended in getting rid of the extra salt consumed.

Not all the extra salt consumed in sea water is excreted, however, for small quantities gradually accumulate in the body. These will eventually lead to salt poisoning which could also cause survivors to collapse earlier than if sea water had not been consumed.

Because sweat contains salt, it may be thought that sweating is justification for drinking sea water. Sweat is a very dilute solution of salt, containing less than one-tenth the concentration in urine. Hence, loss of sweat increases the concentration of body fluids almost as much as the loss of an equivalent amount of pure water. If the salt lost in sweat were replaced without the large volume of water lost with it, matters would only be made worse.

Another point of interest is the effect of sea water on the distribution of water within the body. Part of the water in the body is contained within cells and part outside them. Normally, when water is lost, the water inside and outside

the cells share the loss in proportion to their volume. This keeps the change in concentration, within and outside the cells, as small as possible. The consumption of sea water causes body water to move out of the cells. As most of the symptoms and outward signs of water depletion depend on conditions outside the cells, this movement of water is believed to explain the apparent benefits that have been reported on some occasions after the experimental drinking of sea water for short periods. The cells, however, may suffer severe depletion, those of the brain being the first to fail. This could account for the reported mental derangement of survivors who have consumed large quantities of sea water.

For similar reasons, there is little benefit to be gained by drinking urine. During the first day of water deprivation, urine could probably be consumed to advantage but nothing would be gained by drinking urine after it had become maximally concentrated. A survivor would merely be requiring his kidneys to repeat work that they had already done and could not be expected to do any better.

Sweat could be consumed to advantage if it could be collected, and whenever available in sufficient quantity. Some survivors have consumed the water in blisters with apparent benefit. However, during periods of water deprivation, concentration should be on reducing losses from the body to an absolute minimum, as quickly as possible, and then keeping them at this level. In this condition, there would be little sweat or blister water available for consumption.

3

Providing the Solid Component in a Ration

Because it is seldom known with certainty whether a survivor will have an adequate supply of drinking water, the choice of the solid component in a multi-purpose ration should take into account its ultimate effect on water conservation. As water is so very important for survival, it might be thought that, when weight and space are limited, it would be better to provide nothing but water, rather than reduce the amount of water to include some solid food. This is not so, for water economy is partly dependent on the ingestion of solid food, which also assists in improving and maintaining morale and provides calories which enable work to be performed with smaller demands on body tissue.

Body tissue can also be conserved by keeping physical exertion to an absolute minimum. There should be no aimless pacing up and down, or other movements that are not essential for performing necessary work or maintaining body heat. Unnecessary clothing should be removed while working, but replaced as soon as the work is finished to avoid getting a chill. Under cold conditions, special efforts should be made to prevent loss of body heat. On land, and in lifeboats, protection of some kind can frequently be improvised and it is an advantage for survivors to remain close to each other and in the smallest possible protected space. In the inflatable rubber raft, protection is provided by the tent covering under which the occupants can generally generate enough heat to keep themselves warm and, therefore, alive. The conservation of energy by such means is equivalent to the provision of additional solid food.

It is important that survival rations be designed so that the solid component will be palatable and have the greatest

possible acceptability. This is most important and cannot be emphasized too strongly. During periods of mental stress, many men would sooner go hungry than consume food which is unfamiliar or about which they, themselves, are uncertain. Eventually hunger may drive them to consume whatever food is offering but, by this time, there could be considerable food wastage, there is the possibility of opened cans of food becoming contaminated, and there could develop a marked and unnecessary deterioration in a survivor's physical condition.

Hence, as far as practicable, the food contained in survival rations should be that to which people are normally accustomed. A sudden emergency is not the time to introduce untried novelties. Experience has shown that, in addition to its stimulating properties, the sight of familiar and acceptable foods often marks the point at which a survivor will pull himself together and assist in solving his own problems. The food should also be that which would be highly acceptable to men in a state of dehydration. Coarse, rough-textured or very dry foods, and foods with strong odours and flavours would not be suitable.

The solid components in survival rations must be capable of storage for long periods under a wide variety of climatic conditions. Under such conditions, rations should not only remain safe and palatable but there must be no deterioration in aroma, flavour or texture. This places big demands on packaging which is almost as important as the food itself.[1]

CARBOHYDRATE RATIONS

Men initially in good physical condition, who are following a daily routine of moderate physical activity, will show little alteration in their capacity for physical work after one week on a carbohydrate diet providing about 500 Calories daily, together with sufficient water. Their body weights

[1] 'The Provisioning of Expeditions in the Field', *Proceedings of the Nutrition Society*, *13*, 41 (1954).

may drop 5 per cent or more, and they may suffer from frequent fatigue and occasional spells of dizziness but, if motivation is sufficient, their physical capacity will not be greatly impaired.

By increasing the ration to about 1,000 Calories, there would be less loss in body weight over the same period; the period during which physical work could be performed without serious deterioration would be extended; and other possible benefits could arise from the more stable level of sugar in the blood. These additional advantages would be small in comparison with those gained by providing 500 Calories to prevent the major effects of acute starvation. Hence, in situations where space and weight are very limited, the advantages of providing 1,000 Calories may not be sufficient to justify the necessary increase in bulk.

There are sound reasons why rations providing about 500 Calories should consist of carbohydrate only. In particular, carbohydrate would reduce the breakdown of body protein with a consequent reduction in the volume of urine. For instance, it has been found that the daily consumption of 3 to 4 ounces of carbohydrate in the form of sugar reduces the breakdown of protein to nearly one half, whereas the volume of urine is reduced to approximately the same extent. The mechanism of this effect is not quite clear but its practical importance lies in the fact that 3 to 4 ounces of carbohydrate per day, in any convenient and acceptable form, will conserve more than its own weight of body water.[2] Hence, it is worth including this amount in survival rations even at the expense of a corresponding reduction in the weight of ration water.

Restricted rations, consisting of carbohydrate and water, frequently provide carbohydrate in the form of barley sugar, boiled sweets or some similar hard confection. Such foods are an unfortunate choice because the continuous

[2] J. L. Gamble, in 'Proceedings of the Survival Ration Conference', *Activities Report*, 3, 137 (1951).

sucking of hard confections often causes mouth sores. Furthermore, a considerable amount of energy is unnecessarily expended in sucking or chewing. During the course of a day, this could reach 200 to 300 Calories. Large volumes of saliva are continuously produced, swallowed and reabsorbed with further loss of energy and a possible loss of water.

Barley sugar and boiled sweets contain less than 1 per cent water so that they are very concentrated foods, containing almost 110 Calories per ounce. They are also familiar and generally acceptable to most people. On the other hand, they cannot be stored satisfactorily for long periods without the risk of their becoming sticky and difficult to handle with appreciable loss of food.

Starch jelly is another carbohydrate food sometimes used in the preparation of survival rations. It is a generally acceptable and familiar confection without the objectionable features of barley sugar or boiled sweets. It is made from sugars and starch, with flavour and appropriate colour, and contains about 90 Calories per ounce. Starch jelly may be provided in the form of bars or pieces, both of which are usually coated with sugar. It is seldom sold on the open market as starch jelly, but usually as a sugar-coated fruit jelly or soft jube.

Excluding the sugar coating, starch jelly has a moisture content of about 15 to 20 per cent. It is, therefore, a bulky food in comparison with confections having a much lower moisture content. This need not be a disadvantage if the drinking water in the ration can be reduced to take account of that in the jelly. Starch jelly has a somewhat limited life, the stored product eventually becoming tough and leathery. This does not affect its food value but may make it difficult to consume.

The most satisfactory carbohydrate food is probably glucose in the form of lightly compressed tablets. These tablets may contain about 98 per cent glucose and have an

energy value of almost 110 Calories per ounce. They frequently contain a small amount of acid, and are sometimes given a mild fruity flavour and slightly coloured. They can be consumed as tablets or added to water. When consumed as tablets, they dissolve readily in the mouth leaving a clean refreshing after-taste. When added to water, they provide a pleasant drink, being only about three-quarters as sweet as an equal amount of cane sugar.

Glucose tablets contain practically no moisture, have a long storage life under all kinds of conditions and do not become sticky like barley sugar and boiled sweets, or leathery like starch jelly. They are readily available on the open market in a variety of flavours and flat shapes that facilitate packaging in cans or plastic pouches. Tablets prepared from ordinary cane sugar would be almost as satisfactory and much cheaper. The sweeter taste of cane sugar, in comparison with glucose, places it at a slight disadvantage.

Hence when a restricted ration, designed to cover a period of 6 days with no food on the first and not exceeding about 9 pounds gross weight per person, is required, $4\frac{1}{2}$ ounces of lightly compressed glucose tablets plus 1 pint of water per day is probably the best that can be provided.

In addition, it might be desirable to provide one multivitamin tablet, containing both the vitamin B group and vitamin C, and about eight twenty-grain tablets of common salt per day. Vitamins could probably be incorporated in the glucose tablets, but would serve as an additional morale builder if provided separately. The salt tablets would be for consumption as required by land survivors who have adequate supplies of drinking water. In rations designed for use by sea survivors only, the salt tablets should be omitted.

In service aircraft, limitations on the size and weight of a ration are of particular importance. Rations are frequently stowed in the ejector seat, a device used for escaping from

single and multi-seater aircraft. Hence they must be extremely small and of high caloric density. For this purpose a number of special carbohydrate rations have been designed. They usually consist of some form of sugar, but may also contain compressed malted milk and other specially prepared tablets containing small amounts of fat.[3] The latter are often coated with sugar or chocolate. The number of calories provided by these special tablet rations is generally small and they are used simply because there is not space for anything better.

The provision of chewing-gum is not generally favoured because of its comparatively low caloric density and the calories that it causes to be wastefully expended in continuous chewing.

HIGH FAT RATIONS

Most survival rations are designed to provide more than 500 Calories daily. A ration containing only this number of calories will permit a man to engage in moderate physical activity for a short period, but it will not permit him to engage in very strenuous physical activity, or be in a position to continue normal activities beyond the first week or so. Under many survival conditions, it may be necessary for a survivor to walk, climb hills or paddle a raft for long periods each day with little opportunity for regular rest. Hence, when weight and space are not limited to very low levels, emphasis is mostly on a ration for use under active rather than static conditions.

When a ration containing considerably more than 500 Calories is provided, the extra calories may be largely in the form of fat, since fat provides the greatest number of calories for a given weight of food. The inclusion of excessive quantities of fat, however, should be avoided as this may lead to wastage resulting from fat seepage from the

[3] 'Current Operational Rations', *Activities Report*, 7, 10, 72, 170 (1955).

food itself, or from incomplete fat combustion in the body. In many foods, the inclusion of fat to the extent of about 20 per cent is practicable and desirable. At this level, it would not only greatly increase the caloric density, but improve consistency and perhaps flavour. In some foods it may be included to the extent of about 30 per cent but only in special circumstances can it go much beyond this level.

Because multi-purpose survival rations must be suitable for use under tropical conditions, it is necessary for any added fats to have a high melting point. Liquid oils can now be converted to solid fats, with high melting points, so that this presents no problem. Either high melting point fats can be especially chosen or hardened fats, which are readily available, used as an alternative. Hardened fats appear to be just as well utilized by the human body as the natural oils from which they are derived.

Toffee, fudge and caramel all contain fat and each has been used in survival rations. They are all somewhat similar in composition, consisting largely of carbohydrate in the form of sugars, an appreciable amount of fat and a very small amount of protein. Fudge and caramel are similar in appearance and texture and more filling than toffee which is essentially a chewing confection. Commercial toffee and some kinds of fudge and caramel normally contain small amounts of salt in addition to that which may be included in any condensed or powdered milk used in their manufacture.

Although salt may tend to improve the flavour of a food containing appreciable amounts of fat, it is objectionable when incorporated in a multi-purpose survival ration. For survivors at sea, the unavoidable consumption of sea spray on the lips and fingers would provide small amounts of salt. For survivors on land, who may be perspiring freely, salt can best be provided as a separate item to be taken as required. It should not be taken during physical exertion but during rest periods, the evening being especially suitable.

Toffee can be used to provide fairly high concentrations of fat. Special toffees, containing as much as 30 per cent, have been manufactured but found unsatisfactory during storage under tropical conditions when there may be considerable fat seepage. Toffee containing 15 to 20 per cent fat is generally free from this seepage. Nevertheless, toffee, like barley sugar and boiled sweets, is not a satisfactory survival food because of the sucking and chewing necessary for its consumption. It also tends to produce mouth sores. Toffee has a fair storage life under temperate conditions but may soften and become sticky during storage in the tropics.

Fudge and caramel may also contain 15 to 20 per cent fat as well as carbohydrate present in the form of sugars. As for toffee, the small amount of protein is normally that introduced in any condensed or powdered milk used during manufacture. Fudge or caramel may be provided in the form of bars or pieces. Both can be consumed fairly readily and hence are free from some of the objectionable features of barley sugar, boiled sweets and toffee. They have a fair storage life but, under tropical conditions, may eventually become soft and sticky.

Toffee has a moisture content of about 2 to 3 per cent and fudge or caramel about 8 to 10 per cent. Toffee is, therefore, the more concentrated food. Toffee and fudge or caramel contain approximately 150 and 130 Calories per ounce, respectively, so that almost 7 ounces of toffee, or 8 ounces of fudge or caramel would be needed to provide 1,000 Calories.

There are several other foods containing large amounts of fat that have been successfully used in survival rations. They are of little value as components of a multi-purpose ration but have merit under certain restricted regional or operational conditions. Of these, pemmican deserves a brief mention.

Pemmican is a product that originated with the American

Indians. It is made from dried lean meat and hot animal fat to which other ingredients are sometimes added, but seldom salt. The mixture may be pressed into a brick or contained in some form of bag. Some pemmican may have a fat content of 80 per cent, the remaining 20 per cent consist mainly of protein and a very small amount of water. Because of its high protein content, pemmican increases the volume of urine and should be provided only when it is known that water supplies will be adequate. Because of its high fat content, it has a caloric value that may be as high as 220 Calories per ounce. Hence, pemmican is a ration of particular importance in polar regions. It has a long storage life which, in polar regions, may exceed five years.

LOW PROTEIN RATIONS

In low calorie rations, protein should not be included as it would only be used for providing energy for which carbohydrate and fat are more sastifactory. During digestion there could be considerable loss of calories in the form of heat, and during combustion it would provide less water than carbohydrate or fat and, because of the urea that would be formed, would increase the amount of urine and hence water requirements. At intermediate calorie levels, a small amount of protein could improve the nutritive value of a ration without significantly increasing the heat released during digestion or the loss in body water. It could also improve palatability and would be an aid to men suffering from injury, particularly burns, shock and loss of blood.[4]

Studies on the nutritional requirements of men on various reduced caloric intakes have shown that protein is not utilized as such on intakes less than about 1,500 Calories per day. At this level, it can be included with advantage, but not to a greater extent than about 5 per cent of the

[4] *Therapeutic Nutrition* (National Research Council Publication 234, Washington, 1952).

total number of calories. Animal protein is better than vegetable as its composition bears a closer resemblance to human protein.

There are four foods that could provide a ration containing small amounts of protein. These are sweetened condensed milk, light or dark chocolate, some varieties of biscuit and certain kinds of fruit pudding or cake. All have been used in survival rations although not with equal satisfaction. Some have been included as one of several components in a complex type of ration.

Sweetened condensed milk is whole cows' milk from which a large proportion of the water has been removed and cane sugar added to assist in its preservation. It has a moisture content of about 26 per cent and contains about 94 Calories per ounce. It contains appreciable amounts of protein and salt, the former providing almost 12 per cent of the total number of calories. It could, therefore, make considerable demands on body water and would tend to hasten dehydration if water were in short supply.

Sweetened condensed milk may be provided in hermetically sealed cans or in collapsible metal tubes. In either container, it has a long storage life, the browning that eventually takes place having little effect on its nutritive value. It could be consumed in its unadulterated state or mixed with water as a drink. Either way it would be very sweet and, after it had been consumed for a few days, could become very sickly and even nauseating. This sweetness could be reduced by consuming the milk in conjunction with some bland food but it would be difficult to find a suitable food which would not increase the over-all protein content.

Chocolate may be broadly divided into two types, light and dark, the former being the more popular. The essential difference between light and dark chocolate is that the former contains an appreciable amount of milk and the latter does not. Both provide about 150 Calories per ounce but light chocolate contains more protein than dark. In

light chocolate, the protein may contribute about 5 per cent of the total calories and in dark chocolate about 3 per cent. Both contain small amounts of salt which is also higher in light chocolate than in dark. Despite its comparatively low protein and salt contents, it has been claimed that chocolate is somewhat thirst provoking. This claim needs investigating.

Ordinary commercial chocolate is of little value under hot conditions because of its low melting point. At sub-tropical temperatures it readily develops a bloom that spoils its appearance but does not affect its nutritive value. At tropical temperatures, it becomes soft, loses its shape and there may be considerable fat seepage. High melting point chocolate, in which part of the cane sugar has been replaced with dextrose, has been produced for special purposes. This is very hard at ordinary temperatures but satisfactory under tropical conditions unless there are frequent changes in temperature. Under such conditions the chocolate may eventually disintegrate into a powder resembling cocoa. Nevertheless, it has better keeping qualities than toffee, fudge or caramel.

Biscuits are a familiar item in survival rations and special lifeboat biscuits in hermetically sealed cans are available on the open market. One popular type of lifeboat biscuit contains 140 Calories per ounce. It has an average protein content of about 10 per cent and this provides over 7·5 per cent of the total number of calories. It also contains small amounts of salt. Hence this biscuit, which is probably typical of most lifeboat ration biscuits, is not very suitable as it would not conserve body water to the fullest possible extent. Another unfavourable characteristic lies in its hardness and dryness which could make it difficult to consume by men with dry, parched mouths containing practically no saliva.

A short-textured biscuit, with a soft sugar filling to reduce the over-all protein content, could overcome the

above objections but it is not easy to produce a biscuit of this type with a long storage life. In particular, it would have to contain large quantities of fat and this could result in fat seepage at high temperatures unless specially hardened fats are used. For biscuits, such fats could present manufacturing problems. Furthermore, there may be difficulty in preventing the fat from going rancid during storage, particularly at high temperatures.

If these difficulties could be overcome, a short-textured, sugar-filled biscuit, containing practically no salt, could be suitable for a multi-purpose survival ration. It is an item of food that is familiar and acceptable to most people. Packaging could be in hermetically sealed cans, or sealed plastic pouches. Care would be necessary to ensure that the biscuits do not become contaminated after they leave the oven and before they are finally packed.

Fruit puddings, free from the unsatisfactory features of the foods already discussed, have been produced for use as survival rations. Their caloric value can be adjusted by the addition of a suitable fat, the protein content can be kept at a low level by the inclusion of fruit, and the salt content can be reduced to practically zero. A commercial recipe for a satisfactory pudding is given hereunder:

Currants	60 lb.
Flour	55 lb.
Raisins	54 lb.
Raw Sugar	44 lb.
Suet	31 lb.
Egg Pulp	32 pts.
Whole Milk	28 pts.
Beef Fat	10 lb.
Cream of Tartar	2 lb.
Bicarbonate of Soda	1 lb.
Sodium Ascorbate*	1 oz.
Flavour	—

* Source of vitamin C.

PLATE 3. Compressed Glucose Tablets and Pouch

The pouch is made from a laminate consisting of brown kraft paper, aluminium foil and polythene

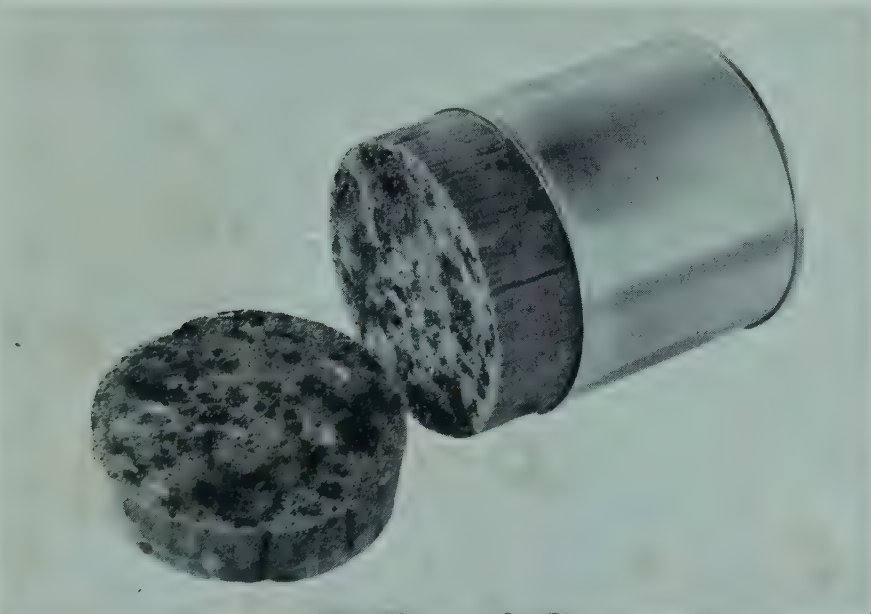

PLATE 4. Fortified Fruit Pudding and Can

One pound of fruit pudding wrapped in greaseproof paper shown after satisfactory storage tests in a suitable metal can

PLATE 5. Cans of Water and Pudding with Spike and Opener
Note diminutive size of can opener

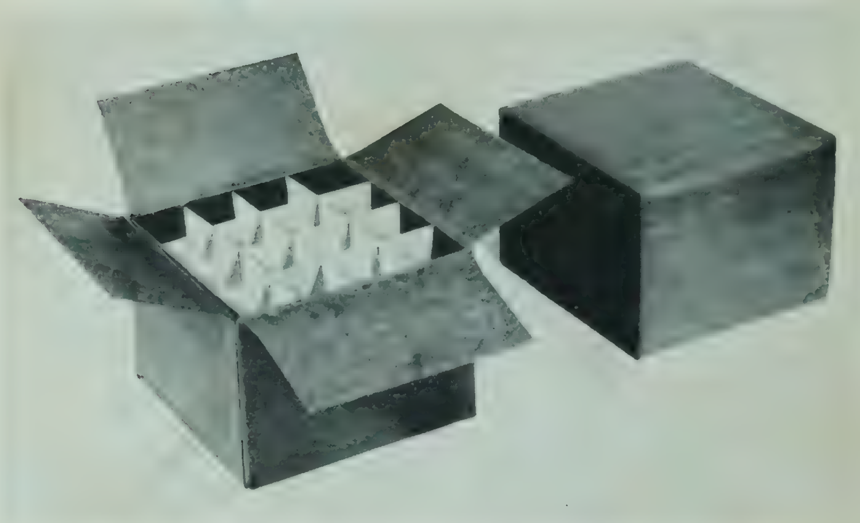

PLATE 6. Container Made from High Wet-Strength Fibreboard
It consists of an outer sleeve and box with an inner liner and lattice

The pudding should also be fortified with vitamins of the vitamin B group, or vitamin enriched flour used in place of plain flour. Common levels of enrichment should be quite satisfactory. Manufacturing procedure should follow approved commercial practice.

A ration of this type would be familiar and acceptable to most people. It has an agreeable appearance and conservative taste. It contains no alcohol although this would assist in conserving supplies of body water, for 1 ounce of alcohol gives, on combustion in the body, approximately 1 1/6 ounces of water. It could also serve as a preservative and might assist in building and maintaining morale. The pudding purposely contains no nuts or citrus rind to ensure that it will not be unnecessarily relaxing. Nuts would also increase the protein content and could be a troublesome source of insect infestation.

The pudding contains about 4·5 per cent protein (animal protein being provided by the whole milk), nearly 11·5 per cent fat (an amount that can be readily incorporated without the possibility of subsequent separation) and 57 per cent carbohydrate. It provides about 1,500 Calories per pound which are contributed on approximately the following basis:

	Calories	*Per cent*
Protein	80	5
Fat	470	30
Carbohydrate	1,030	65
Total	1,580	100

The pudding has a moisture content of about 25 per cent and, because of this, is bulkier than many other foods. The moisture content of biscuits is only about 6 per cent. Bulk, due to a high moisture content, need not be a disadvantage. Water is of equal value to the body whether it is supplied as a component of the solid part of a ration or as a drink. Hence, if 16 ounces of pudding, containing

25 per cent moisture, is to be provided as the solid component of a ration, the water component can be reduced to the extent of 4 ounces per day without any reduction in the total amount of water provided. In other words, $6\frac{1}{2}$ pints of drinking water and 5 pounds of pudding containing 25 per cent water are equivalent to $7\frac{1}{2}$ pints of drinking water and $3\frac{3}{4}$ pounds of solid food containing no water.

When a survival ration is designed to cover a period of six days, with no food on the first, and cannot exceed about 16 pounds gross weight per person, the above quantities of water and pudding, namely 1 pound of pudding and 1·3 pints of water per day, would probably comprise the most satisfactory multi-purpose survival ration yet devised. If the ration is intended for use on land, where survivors may have adequate supplies of drinking water, about eight twenty-grain tablets of common salt per day should also be provided.

The daily ration of pudding can be provided in an hermetically sealed can or in several plastic pouches. When canned, the pudding is practically sterile and has a life of at least two years and frequently longer. When it is to be provided in plastic pouches, the pudding is first made in the form of a slab, cut into slices and then packaged. By this method its storage life may be reduced, although not necessarily so. The chances of contamination from outside sources after the pudding has been cooked and before it is packed are greater.

Other types of survival rations containing small amounts of protein consist of compressed food bars. These may contain meat or fruit with smaller amounts of cereal and other constituents. They are usually palatable enough when freshly made but may deteriorate fairly rapidly on storage. Under conditions of stress, they are not likely to have a high degree of acceptability because of their generally unfamiliar appearance and taste as well as their hard and tough texture. Training before an emergency could do

much to increase their acceptability but this is not always practicable.

With regard to training, it is important to note that the more times a person starves, the better he is able to exist under starvation conditions. Hence, for a person likely to be involved in a situation requiring him to live on a survival ration, one or more periods of starvation, during an initial training period, could be of great assistance.

HOT BEVERAGES

Experience has shown that after a sudden disaster during which lives have been threatened and probably lost, the best means of relieving shock and restoring morale is to provide a hot, strong drink of a kind to which the survivors are accustomed. For most people this would be tea or coffee, although cocoa and soup could also be used for the purpose. Unfortunately, the conditions that generally exist at sea, and sometimes on land, do not permit the heating of water even when adequate supplies of water are available. Nevertheless, there should be a place for beverage-making materials in survival rations designed for special conditions where the preparation of a hot brew is likely to be possible.

Tea or coffee may be provided in the form of soluble powders or lightly compressed tablets, and milk and sugar in the form of instantly soluble milk powder and loaf sugar. Single tablets containing tea or coffee, milk powder and sugar are also available. Cocoa, or soup, in the form of powders or cubes, would be equally satisfactory for the preparation of a hot beverage. Waterproof matches or vestas, and solid fuel, such as hexamine tablets, could serve for providing heat. The container which held the water could be used as a utensil for heating the beverages. Self-heating soups and similar foods are available but too bulky for inclusion in most survival packs.

FOOD AFTER RESCUE

When a survivor is eventually rescued, he will need

proper food and, if he is in a state of starvation, plenty of it. There is no evidence supporting the popular belief that a starved man needs carefully nursing back to a condition in which he can take a full diet. Even when near the point of death, it has been found that starved people can, with few exceptions, swallow and digest relatively large quantities of simple food mixtures.[5]

Pre-digested foods are not essential for resuscitating survivors even when they are in the last stages of exhaustion from starvation. There is no evidence that a starved person's ability to digest food is impaired, and the importance of placing a starving person on a diet with a high energy and protein content cannot be over-emphasized. On such a diet, recovery is generally so rapid that, within a day or two, a survivor can consume considerable quantities of food.

For survivors who have been on a low water intake, and whose mouths may be in a parched and tender condition, fluid and soft foods are desirable. These can be prepared using whole or skim milk powder as a base. The essential difference between these two products is that the former contains about 27 per cent fat and the latter, 1 per cent. There is no evidence that survivors suffering from starvation cannot utilize the large amount of fat contained in whole milk powder.

Milk powders can be used to prepare a wide variety of foods, including various kinds of drinks, custards and puddings. Custards also contain eggs, whereas bases for milk puddings may consist of rice, sago or tapioca. All these foods can be served hot or cold according to circumstances and the survivors' preference. Regarding the latter, a final word of caution may not be out of place.

Apathy and irritability are outstanding features in the condition of a survivor suffering from severe and prolonged

[5] *Malnutrition and Starvation in Western Netherlands* (General State Printing Office, The Hague, 1948).

shortage of food. Hence his peculiar psychological state makes it necessary to pay the utmost attention to methods of approach and the manner in which food is served. Otherwise the greatest difficulties may be encountered.

4

Possible Supplementary Sources of Food

When designing a survival ration, it is useful to have some idea of the supplementary sources of natural foods likely to be available to survivors. Many people have incorrect ideas regarding the natural foods of foreign places. It is frequently believed that the jungle contains so many poisonous plants that none should be consumed, and that the oceans abound in fish that can be readily caught and eaten raw. Actually the jungle contains some poisonous plants, but they are comparatively few, and many sea survivors would have the greatest difficulty in catching fish and, in any case, they may be better without them.

It is important to know whether the natural foods likely to be available can be consumed raw or whether they should be cooked. If they should be cooked, consideration could be given to the inclusion of matches and perhaps some form of condensed fuel such as hexamine tablets. It may be considered an advantage to select containers for holding the ration that can be used later as cooking utensils, and to include a metal or plastic reclosure lid. It may also be worth including a short piece of wire from which a handle can be made.

Apart from making most natural foods more palatable and starchy foods easier to digest, cooking can make some foods safe to eat. For instance, the leaves of a few food plants, such as taro, contain enormous numbers of minute, needle-like crystals which are intensely irritating in the uncooked leaf, although not actually poisonous. These crystals are removed during cooking. Other food plants, such as some varieties of cassava, contain an acid that is deadly poisonous. This acid is removed by boiling the edible tubers in several

changes of water, and discarding the water after each boil. On the other hand, some poisonous varieties of mushroom are not made safe by cooking.

As well as removing any harmful crystals and soluble poisons, cooking makes foods safer by killing bacteria and harmful parasites. This is most important with regard to animal foods, such as the flesh of animals, birds and fish, and particularly for the organs of animals and all forms of fish obtained from fresh water. It is also important with regard to insects. Grasshoppers and crickets with the legs and wings removed may be toasted on the end of a stick or fried in coconut oil. Winged ants or termites, and the eggs of ants, are not only made safe but more palatable by cooking. On the other hand, many varieties of caterpillar are poisonous even after they have been cooked.

There are, of course, many natural foods that can be safely consumed without being cooked. They include recognizable fruits, berries and nuts as well as such foods as nectar and wild honey. For prolonged periods of living under survival conditions, it is important that some fresh foods be included in the dietary as many vitamins would be destroyed, and minerals leached out, during the cooking methods already described. These fresh foods should include fruits, berries and nuts that can be recognized, or have passed the test described below.

In any instruction sheet accompanying a survival ration, a test for determining the safety of unfamiliar foods should be described. The following test has been found useful and practicable:

(a) first, the food should not produce skin irritation when handled, nor contain a milky juice, and it should be free from putrefying and objectionable odours;

(b) next, a small portion held inside the lower lip for a few minutes should not cause irritation nor produce a burning, acrid, bitter or soapy taste;

(c) finally, the consumption of a small portion, well

chewed, should not produce any ill effects within a period of at least 8 hours.

If a food, in the form in which it will be consumed, passes this test, moderate amounts may be consumed with reasonable safety. There are, of course, some well-known foods that will not pass the test, but are known to be safe to eat. For instance, durians have a most objectionable odour, figs contain a milky juice and lemons have a bitter taste. In addition, woody and fibrous foods should be consumed in comparatively small amounts as they can be very relaxing.

Food consumed by birds and animals is not a reliable guide to food that can be consumed by man. For instance, pigeons can eat the berries of the strychnine tree which are highly poisonous to man. In general, the food consumed by monkeys can be consumed by man. There are, however, exceptions due to the fact that, over a period of time, monkeys build up an immunity to certain food toxins. This also applies to natives who can consume large quantities of some foods that would make a white man very sick.

Some of the more important foods likely to be available to survivors in particular regions will now be briefly discussed.

COASTAL FOODS

If at all practicable, the objective of most survivors, whether on land or sea, will be to reach the nearest coastline where natural foods are comparatively plentiful and chances of survival generally favourable. In addition to edible plants, which will vary according to climatic conditions, there will usually be a variety of seaweeds, shellfish, fish and birds.[1]

On most tropical coasts, coconut palms will generally be found. The green coconut contains large amounts of a

[1] *Living off the Southwest Pacific Tropics*, Information Bulletin, No. 5 (A.A.H.Q., New York, 1944).

refreshing liquid as well as a small amount of soft white flesh, both of which are delicious. The mature nut contains less liquid but a larger quantity of firm white flesh. During germination, the liquid and flesh change to a spongy mass that can be eaten raw or toasted in the shell over a fire. The sprouts of germinating nuts and the tender white heart at the top of the trunk may also be eaten.

On many tropical coasts, particularly in and around the Pacific Ocean, the pandanus is to be found. This is a big-headed tree with drooping saw-edged leaves, large reddish, oval-shaped fruits and a trunk propped up by air roots. The segments of the fruit are edible. The sweet juice may be sucked out, or the segments cooked for about an hour, or dried out in the sun. The bud found in the centre of the whorled leaves may be eaten if baked. Pandanus flour, made from the fruit, will keep for many months.

In more temperate climates, the wild relatives of familiar fruits, such as cherries, blackberries, persimmons and oranges, may sometimes be found and are usually safe to eat. Familiar nuts, such as acorns and beechnuts, may also be eaten and, if bitter, they should be prepared by soaking in water. They taste best, however, when boiled or roasted. Vegetable foods resembling beans, cucumbers, melons, tomatoes, parsnips and onions should be regarded with suspicion as they could be poisonous.

The poisonous substances in some plants may be distributed throughout the entire plant but are usually concentrated in some particular part, such as the roots or seeds. Juicy and pulpy fruits, if they smell and taste wholesome, are nearly always safe, providing the seeds are discarded. In tropical regions, red fruits should not be eaten until tested even though they have a pleasant odour and attractive appearance.

Seaweeds are edible and resemble land plants in being predominantly carbohydrate in composition. Like green vegetables, they supply bulk, vitamins and minerals and

they are useful for adding to other foods. They are not very salty, the water they contain being moderately fresh. A common classification is according to colour: brown, red, green or blue-green. In general, the red, green and blue-green are the most palatable, most brown seaweeds being too tough.

Seaweeds can be eaten raw and there is no evidence that any are poisonous. Nevertheless, they taste better and are generally more acceptable when cooked, particularly if used as an addition to other foods. They should be firm and slippery. Those with a fishy or putrid smell, or which are wilted and decaying, are unfit for consumption.

Shellfish can be found on coasts almost anywhere in the world. Limpets, and snails that creep on rocks are usually more plentiful than any other. Chitons can be found on rocks, and mussels, scallops, oysters, cockles and clams, on rocks or mud flats. Only live shellfish should be collected and they should not be taken from colonies in which many are dead. When alive, they cling more closely to rocks and close their shells or move in some other way when touched. A knife or other sharp implement is useful in removing and opening some forms of shellfish.

With one possible exception, all shellfish are edible. The exception is the black mussel, found on some northern coasts of the Pacific Ocean, and which is sometimes poisonous. The group of shellfish known as 'cones' are dangerous because of their poisonous teeth. The cones consist of a single cone-shaped shell that may be in various colours and designs. However, all shellfish with one shell are not cones and the others including mutton fish, periwinkles and whelks can be freely caught and eaten. All freshwater shellfish, as well as land snails, should be cooked as they may have lived in contaminated waters and could be infected with deadly lung parasites as well as bacteria. Cooking makes them both safe and more palatable.

Sea urchins, which look like animated coloured pin-

cushions, contain edible food. This consists of the large red and yellow egg masses that they contain and which may be eaten raw. Sea cucumbers also consist of edible food. The insides are removed and all slime scraped from the outside. The flesh may then be boiled, or partially cooked, cut into pieces, and added to other foods. Jelly-fish and sea-worms should not be eaten.

Crayfish, lobsters, crabs, prawns and shrimps, as well as land crabs, are edible and easily caught. It is generally a help if sufficient material is available to make a crude basket or trap in which a piece of bait can be placed. If obtained from fresh water, such foods should always be cooked but, whether obtained from fresh or salt water, they are made more palatable by cooking. Turtles are also good to eat and turtle eggs buried on beaches may be located by digging or poking the sand with a stick.

Most coastal fish are safe to eat but there are a few that are poisonous. These can often be identified because of their unusual appearance. Their bodies are seldom a regular fish shape and some are self-inflating. Frequently they do not have ordinary scales but are covered with rough or spiny scales and, in some instances, have no scales but spines or bristles. The jaws of one group have an enamel-like covering without distinct teeth.

Toadfish are some of the most dangerous. They can be readily identified because of their oval or pear-shaped bodies and power of self-inflation. They often have a peculiar and disagreeable smell and may grunt when taken from the water. Many other small venomous fish resemble the weeds among which they lurk. Hence, care should be taken in handling or collecting sea-weed.

A determination of the edibility of some fish is complicated because there is evidence that some reef and lagoon fish found in parts of the Pacific Ocean, and perhaps elsewhere, become poisonous for part of the year when they feed on certain poisonous substances.

Fish spoil easily and it may so happen that more fish are caught than can be immediately consumed. To preserve the excess, they can be cut into thin strips ½ to 1 inch in thickness and dried in the sun or over a smoky fire. In damp, warm weather, the fish should be re-dried daily. This method of preservation can also be applied to the flesh of any birds that may be caught in quantity in coastal regions.

Some of the fish and carrion-eating birds have a very strong flavour and may not be particularly palatable but they are of value if nothing better is available.

JUNGLE FOODS

A comparatively small section of the world's surface consists of jungle, a term used to describe any natural uncultivated forest in tropical or sub-tropical regions. It may consist of wet rain forest or dry open scrub and is not always constant in composition even in the same climatic zone. Its vegetation depends on altitude and, to a large extent, on the influence of man throughout the centuries. Untouched primeval virgin forest is usually referred to as primary jungle, whereas that which has been cleared by man, but reclaimed by the jungle, is known as secondary jungle. Primary jungle consists of large mature trees many hundreds of feet high, whereas secondary jungle consists of smaller trees, undergrowth and vines.

Both primary and secondary jungles are unpleasant places through which to travel and difficult places to find food. The soil is covered with dead and rotting vegetation over which leeches move in countless millions. Apart from a few nuts or fruits that may have fallen to the ground, the only available food will often be restricted to ferns and palms.[2] The tips and shoots of ferns and the entire leaf of

[2] *Jungle Survival* (Air Ministry Pamphlet 214, London, 1950).

some, such as the birdsnest fern, are safe and good to eat either raw or cooked. The young shoots of most palms, including the climbing rattan palm, are also safe to eat, although those with a strong burning taste should be avoided as well as those with feathery leaves or small silvery scales especially on the under side.

Many vines are a good source of refreshing liquid. The liquid should never be sucked direct from them, as the surface may irritate the lips. It should be allowed to flow into a clean empty can or other container. The juice from vines with a milky sap should never be consumed. Bamboos, particularly the old yellow stems, may provide appreciable amounts, but a heavy knife or similar implement is necessary to release it. They also provide succulent young shoots that may be eaten.

Along the edges of a jungle, food plants are usually more plentiful. Many plants, particularly those growing in swamps or wet ground, have enlarged roots or bulbs. These could provide the most abundant and readily available sources of jungle food. Most are edible but a few are poisonous in various degrees. Water lilies are safe but there are other lilies and plants with onion-like bulbs that should never be eaten. Unless they can be definitely identified, all such foods should be tested before they are consumed.

Many grasses have succulent young shoots that can be eaten. Wild sugar cane, with a stalk rich in sugar, provides nourishing food. The seeds of all grasses and grass-like plants can also be eaten. Some wild grasses have fairly large seeds which, after removal of the husk, may be either boiled or roasted. The very young flowering parts, as well as the peeled roots, can sometimes serve as food.

In some regions, sago palms may be found. The sago palm stores great quantities of starch in its trunk. This starch is valuable food and forms the basis of many native diets. To obtain it, the palms are felled, the trunks split open, the soft inner parts crushed and the pulp washed out

and allowed to settle. The water is then drawn off and the resultant mass allowed to dry when almost pure white starch results. One trunk, cut when the flowers are due, will yield as much as 600 pounds of starch. To obtain sago starch, an axe or similar heavy implement is necessary.

In many parts of the tropics, the local people live in small isolated villages and grow their food in nearby gardens or small clearings. If a garden can be found, usually there will be people living nearby or, if the garden is abandoned, there will be some forms of edible food, such as taro, yams or cassava, in a semi-wild state. Edible roots can usually be removed with a sharp, strong stick and fruits and berries obtained by climbing for them.

All birds and their eggs are edible unless the latter have spoiled. Unspoiled eggs may be eaten even if there are live embryos inside them. Bats may be found in caves, and rodents and other small animals are most plentiful and easiest to find near stretches of water, in open spots in the jungle, and along the edges of swamps. All provide animal protein which would be a valuable addition to a survivor's diet of plant food.

In some swamps, waterholes and rivers, freshwater fish may be found. All freshwater fish are edible, although some have poisonous spines. They should be cooked before being eaten because they may contain parasites that can make a man very sick. Land crabs, particularly those in parts of Asia, are often infected with a lung parasite that may prove fatal to man if the crabs are eaten uncooked.

All warm-blooded hairy animals are edible but most of them are wary and difficult to capture. Wild pigs may sometimes be caught but their flesh should never be eaten unless well cooked. Snakes and lizards may be eaten but the heads should be cut off the former as soon as they are caught to remove their only source of venom. Frogs and toads are good to eat but should be skinned as some kinds have poison glands in their skin.

OCEAN FOODS

Oceans and seas occupy more than two-thirds of the world's surface and they are two-and-a-half times as extensive as all the great continents together. Their waters contain about 3·5 per cent salt although the amount varies from about 4 per cent in the Red Sea to 3 per cent in polar seas. Fish are the principal inhabitants and, for some survivors, they can form the most important source of supplementary foods under certain conditions.[3]

Fresh fish contains about 80 per cent water, the remaining constituents consisting mostly of protein and sometimes appreciable amounts of fat. It is almost impossible to extract this water by means likely to be available to a survivor at sea and the only way in which it can be consumed is by chewing the flesh and spitting out the residue. If the flesh is eaten, considerable quantities of protein would also be consumed, and the extra urine necessary to remove the end-products of protein combustion would probably offset any advantage that could be gained from the water contained in the flesh eaten. Hence, when drinking water is in short supply, fish should not be eaten. However, there may be conditions under which ample water is available, such as after repeated heavy rains and, in these circumstances, fresh or dried fish may be freely consumed to advantage.

In the open ocean far from shore one does not generally find the rich fish life frequently believed to be typical of these waters. The marine forms mostly encountered are whales, porpoises and sharks, together with limited varieties of small fish similar to those found in coastal waters. It is these smaller fish that may be caught on light makeshift tackle, or by other devices, and that are likely to be of the greatest importance to the survivor fortunate enough to have sufficient water.

[3] *Survival at Sea—Inflatable Liferafts* (The Maritime Press, Wokingham, England, 1957).

A small fish found in both coastal and ocean regions is the flying fish of which there are about 20 or 30 different kinds. At night, it will sometimes fly into a boat or raft, or may be induced to do so by the survivor holding a piece of white cloth, such as a sail or shirt, so that the light of a lamp or the moon falls on it. Flying fish are easy to handle and they make excellent food. Other edible fish that may be caught are skipper, garfish and trigger fish. The first two are similar in appearance, skipper usually being found far out at sea swimming in large schools, whereas garfish are largely coastal, many varieties confining themselves to estuaries and bays. There are also many coastal varieties of trigger fish as well as some that are found far out at sea. They frequently congregate around a drifting raft and have the peculiar habit of rolling over on their sides and appearing to stare.

Most fish can be eaten without ill effects but there are a few that are poisonous because of toxins produced in their tissues, and others that cause excruciating pain, and sometimes death, by stinging with their spines. Unfortunately, no hard and fast rules can be laid down for distinguishing fish likely to be poisonous or venomous. However, poisonous fish are mostly confined to coastal waters and are seldom found at sea.

Toxic poisoning that results from the eating of certain kinds of fish should not be confused with bacterial poisoning that results from eating any fish that has become contaminated with harmful bacteria. These bacteria are normally killed during the cooking of fish but could cause trouble to survivors who have to eat their fish raw.

In addition to their teeth, most fish have spines in their fins and some have spikes on their heads as well. These are capable of wounding anyone handling them. In most instances, such wounds heal without complication, provided no dirt, germs or fish slime enter them. Some fish, however, have venom glands associated with their spines and these

make them particularly dangerous to handle, although they are safe to eat. These include stingrays.

Inhabiting all oceans and seas are immense numbers of minute animals and plants collectively termed plankton. Plankton are consumed by many fish and are also suitable for human consumption. In the early hours of the morning, when plankton rise to the surface, small quantities may be obtained by dragging a very fine net behind a moving lifeboat or raft. Plankton is quite tasty in small amounts, but very salty. Unless ample drinking water is available, it should not form part of a survivor's diet.

DESERT FOODS

There are more than fifty important deserts in the world and their areas range from about 300 to 3,000,000 square miles. Together, they comprise approximately one-fifth of the world's land area. All deserts have certain things in common, scarcity of water and great extremes of temperature being outstanding characteristics. Surface water is absent over great areas for months at a time so that plant and animal life is sparse and mostly concentrated in the vicinity of oases. In fact, there are large parts of some deserts that are practically lifeless for indefinite periods. Sometimes there are permanent lakes but, if they are without outlets, the water will invariably be salty.

On some desert plains, there may be a little grass from which seeds and roots can be gathered, pigweed and cactus that are edible and can provide liquid, and a few thorny bushes that are practically inedible but may be of assistance in lighting a fire.[4] Other wild plants may sometimes be found around water-holes or along dry stream beds. Even though the upper part of the plant may have died off, or disappeared, the roots can occasionally be obtained by digging for them. Care should be taken to avoid cactus-like plants with a milky sap as they may be poisonous.

[4] *Desert Survival* (Air Ministry Pamphlet 225, London, 1952).

Palms found in the vicinity of water-holes may provide dates. There is also the palm cabbage, a tender shoot that extends from the top of the trunk at the point where the leaves spread out. It may be eaten raw or cooked. There may also be other food-bearing plants or trees that have grown from seeds left by travellers. In this case, they will almost certainly be edible although, if they are unfamiliar, they should be tested as previously described before being consumed.

Birds and animals are rare in most deserts because there is usually little water or cover. The most common animals, found near sources of water when there is cover, are small rodents and lizards. Both are edible, the meat from the hindquarters and tail of the lizard being preferred. In open parts of the desert, gazelles and antelopes may sometimes be seen but are not easy to capture. The meats from all these animals would consist mostly of protein and, unless sufficient water is available, a survivor would probably be better without them because of the increased flow of urine that results from the consumption of all protein.

POLAR FOODS

In the south, the polar region includes the various antarctic territories enclosing the South Pole, and in the north, the Arctic Ocean and various islands and northern parts of the continents surrounding it. Precipitation of moisture is chiefly in the form of snow and under this snow much of the Antarctic continent lies permanently buried, whereas the greater part of the Arctic Ocean consists of sea-ice.

On the sea-ice in the Arctic, and on the permanently buried parts of the Antarctic, there is no plant life and practically no birds or animals. Seals may be seen near stretches of water and, in the Arctic, polar bears and white foxes. The foxes exist on the sea-ice by consuming the remnants of seals killed but not completely devoured by the

bears. Fish and many other forms of sea life may exist where there is water but would be very difficult to catch. Hence, in these frozen desolate wastes, the only supplementary food likely to be available to a survivor would be water.[5]

In slightly warmer regions, but where it is still too cold for trees, there may be found various forms of plant life, including mosses, lichens and small bushes. Most mosses are edible after they have been soaked or cooked in water, but provide almost negligible amount of food. Lichens are coral-like, or disc-shaped plants that have no flowers, leaves, stems or roots. They also have little food value and should not be eaten until after they have been cooked or soaked in water. Some contain a bitter substance but this is removed during cooking. Berries may be found on some small bushes. These bushes are usually dwarfed, grow flat on the ground and may be partly covered with snow and lichens. The berries are usually underneath and one bush may provide a handful. The young shoots and leaves of most bushes may be eaten, but a few contain a poison or have a disagreeable taste. Hence, all berries and leaves should be cooked by boiling, changing the water at least once, and then tested as previously described.

As the climate becomes warmer, plants, and hence birds and animals, become more plentiful. Birds are often easy prey and can sometimes be trapped on their nests. Their eggs are also good to eat. On the shores of the Antarctic continent, penguins, petrels and gulls are likely to be available in large numbers at certain times of the year, and all can be consumed although their flesh may have a rather strong flavour. Fish and various other sea foods may be caught or collected but often with difficulty because of the treacherous nature of the shore-line.

Under polar conditions, as distinct from conditions at

[5] *Army Air Forces Survival* (AAF Manual 64-0-1, Washington, 1945).

sea or in the desert where water is limited, any edible food can be consumed at will. Because of the need to consume sufficient calories to maintain body heat, the fat as well as the lean parts of animals should be eaten.

5

Packaging Survival Rations

THE principal difference between the packaging of foods for domestic consumption and those for use as survival rations is in the degree of protection afforded. Commercial packaging is designed to meet the comparatively moderate requirements of normal transport, storage and distribution. On the other hand, the packaging of survival rations must be such that it will maintain its contents in a sound and acceptable condition for long periods of time under very adverse conditions.

Some survival rations are stored in lifeboats or rafts on the decks of ships where they may be subjected to the corrosive action of the sea and may have to withstand extreme temperature changes as the ship moves from cold to hot regions. Other rations are carried aboard aircraft and, because they may have to make many trips before an emergency occurs, they must be able to withstand repeated ascents to and descents from altitudes at which aircraft normally fly.

It is important to realize that, no matter how excellent the packaging, it can only preserve a relatively stable product. If a ration will naturally deteriorate, no package is capable of postponing this deterioration. For instance, if ordinary commercial chocolate is sent to the tropics, no form of package can prevent this chocolate from becoming soft. Similarly, no package is capable of improving the quality of a product. Packaging can, however, protect a ration from the hazards of transport and handling, exposure to rain and sea spray, and attacks by rodents, insects and bacteria.

A gain or loss in moisture content is probably the principal cause of spoilage due to poor packaging. The change may be relatively simple and reversible, such as the loss of crispness in biscuits, or it may be more complex as in the hardening of fruit and cereal bars. The gain or loss in moisture is not necessarily caused by the external atmosphere entering through a faulty external container. It can take place between two different components packed in the same container that do not have a sufficient moisture barrier between them.

Economy in space and weight, as well as the ease with which the packed ration can be handled, stored and issued, under emergency conditions, are also important. Other important considerations are availability and price. Unless a container is already available on the open market at a reasonable price or can be cheaply produced in volume from available materials by a number of manufacturers, it is of little value for survival purposes. It is important to remember that survival rations are in greatest demand during times of national emergency. Hence, it may not be advisable to choose the material most suitable for the purpose if that material is likely to be in short supply when it is needed in greatest quantity.

Having decided upon the kind of container and the material of which it should be made, it is then necessary to determine whether the container can be filled, closed, and subjected to any other necessary processing with equipment already installed in factories manufacturing the food of which the ration will consist. If the food has to be taken elsewhere to be packed, the cost of production will almost certainly be increased and there may be a deterioration in the quality of the product.

More detailed aspects of packaging survival rations may be considered under three headings—the immediate container, the intermediate container and the ultimate container. For each, a complex array of materials is available

and, in general, there is no difficulty in meeting all but the most unusual requirements.

IMMEDIATE CONTAINERS

Many kinds of immediate containers have been used for holding the individual components of survival rations but there are three that are more suitable than any others. They are rigid metal cans, plastic flasks and flexible pouches.

Metal Cans

Hermetically sealed metal cans, made from standard gauge tin-plate, rate exceptionally high as food containers for most purposes. They provide one of the best means of packaging the greatest variety of foods for the widest range of situations. This is particularly important for multi-purpose survival rations that must be packed to endure extreme climatic conditions.

Metal cans are completely waterproof and gasproof and resistant to all forms of attack by bacteria, insects and rodents. They will stand rough treatment better than almost any other form of food package. Their outer surface is resistant to corrosion under normal storage conditions although some corrosion may take place in the tropics and at sea. For this reason, metal cans containing survival rations should be externally lacquered or painted after they have been filled and closed.

Metal cans are made in a large number of shapes and sizes, some of which are more suitable for holding survival rations than others. For economy of space, rectangular cans are generally better than cylindrical. This, of course, depends on the shape of the space into which the cans are to be stowed and it is not necessarily true for all spaces of an irregular shape. If it is intended that the individual components be stowed about the clothing of a survivor, then flat rectangular cans are best. On the other hand, flat

rectangular cans are less satisfactory than cylindrical if they are to be used later as drinking vessels.

All cans should be such that they can be readily pierced or opened by a man with cold, numbed fingers and restricted arm movement. This would normally require a small can opener or metal spike of the kinds illustrated. The opener is only $1\frac{1}{2}$ inches long by $\frac{5}{8}$ of an inch wide and there should be one with each survival pack. Cans with a key attached, opened by tearing out the top or tearing a narrow strip from around the body of the can, are unsatisfactory for water, and not entirely satisfactory for solid foods. Furthermore, the chances of a survivor cutting himself during the opening process are great and the resultant sharp flexible edge is less satisfactory when the can is used for drinking purposes than the rolled edge of a can from which the top has been cleanly removed with a can opener.

Secondary uses for which the can may be required are worth careful consideration. After the contents have been consumed, a can may be needed for many purposes but particularly for holding or carrying water, and as a drinking or cooking utensil. For these purposes, less spillage is likely to occur with a deep than a shallow can, and there will be less evaporation of water. A plastic or metal reclosure lid that presses onto the opened end of a cylindrical can will improve its use for storage purposes.

A metal can about 4 inches in diameter by $3\frac{1}{2}$ inches in height would be suitable for the 16-ounce pudding discussed in detail in chapter 3. Alternatively, a taller can with approximately the same volume could be used. Such cans would weigh 3 to 4 ounces, bringing the gross weight of the pudding to nearly 20 ounces.

Metal cans may also be used for providing water, a can measuring approximately 4 inches in diameter by $3\frac{1}{2}$ inches in height being sufficient to provide 1 pint of water. For a larger quantity, the can would have to be correspondingly greater. The head space allowed for canned water is larger

than that for other canned foods. This prevents the can from bursting if the temperature drops below freezing point, and it also gives the can a certain buoyancy.

Plastic Flasks

Plastics, consisting of synthetic materials capable of being moulded into various forms, have been in existence for many years and most people are familiar with the earlier products made from celluloid. Plastic containers for the packaging of food, however, were much later in assuming importance and, at first, their use was largely restricted to certain types of food with a relatively short storage life.

Some of the factors that have retarded the use of plastic containers for foods have been their high cost, inability to provide adequate protection, transfer of off-flavours and odours, and inability to withstand processing temperatures. Many of these difficulties have now been overcome and, when used as containers for loose, dry foods or drinking water, plastic flasks made from polythene (or polyethylene) have some advantages over metal cans. In particular, they are lighter in weight, can be refilled and re-stoppered, are less hazardous to the fabric of a liferaft and can cause less damage to protective packaging.

Polythene flasks can be used as containers for glucose tablets and similar dry foodstuffs that do not have to be heat processed in their containers, and do not cake, bond or become sticky on storage. The flasks should have a wide neck and be fitted with a large screw cap that provides an airtight seal. The larger the cap, however, the more difficult it is to obtain a satisfactory seal. Nevertheless, for foods in tablet form or in pieces, plastic flasks can be wasteful of space, and are expensive. They serve better as containers for water.

Unfortunately, the physical properties of polythene are such that water cannot be processed after filling in a way

that would ensure sterility. Hence an aseptic filling procedure is necessary. This means choosing a very pure water that has to be chlorinated. The incorporation of a small amount of carbon black into the polythene prevents any objectionable flavours or odours developing during storage. This requires the manufacture of a special product that places the use of polythene flasks for water storage at a slight disadvantage.

The flasks should have screw caps, and the caps must not only be watertight but must be able to withstand the pressure developed by water on freezing. The caps enable the flasks to be used repeatedly for the holding of liquids, but, unlike metal cans, they have few other secondary uses.

Plastic containers, made of two parts that fit together and which may be sealed with adhesive tape, are available and may have some use in the packaging of rations for special purposes. Their use, however, would be restricted. They may be unsatisfactory for several reasons. If the plastic is too brittle, it may crack during rough usage or, if it is too flexible, it may be difficult to maintain a satisfactory seal. Both conditions would permit the transfer of moisture.

Flexible Pouches

With the development of self-service stores and supermarkets, the wrapping of domestic consumer packs has expanded enormously. Wrappers used for this purpose include flexible wrappings made from such materials as cellophane, pliofilm and polythene. They also include more complex laminated wrappings in which one or more of the above materials have been bonded with metal foil and/or paper.

One of the earliest packaging laminates to provide a high degree of resistance to water vapour transfer consisted of kraft paper laminated with asphalt to aluminium foil which, in turn was laminated to pliofilm. While the foil provided the bulk of the moisture protection, the kraft

paper provided the necessary strength, protected the foil from damage on the outside, and combined with asphalt to provide additional resistance to water vapour. The pliofilm protected the foil on the inside, provided heat sealing properties, and also added to the strength and water protectiveness of the sheet. The foil normally used was aluminium although lead has been used when aluminium was in short supply. Similarly, cellophane has replaced pliofilm when rubber was in short supply.

A laminate consisting of brown kraft paper to aluminium foil to polythene has been found satisfactory for wrapping some ration components. The polythene has the advantage that it remains flexible at both high and low temperatures, and it can be heat sealed. By treating the outer surface of the kraft paper with a water-repellent lacquer it can be made waterproof at little extra cost. Pouches or other flexible types of containers made from this laminate would be suitable for packaging the glucose tablets already discussed. The size of the pouches would depend upon the size and shape of the tablets, 5 ounces of glucose tablets having a volume of approximately 8 cubic inches. The pouches could also be used for pieces of cake and biscuits, but an inner wrap may first be necessary for confections that are likely to become sticky.

Certain ration components, such as biscuits and others containing much fat, deteriorate in the presence of air. The quantity of air that can cause spoilage is usually very small, and it is absolutely essential that packs containing such foods be completely airtight. It is also a considerable advantage if the components are vacuum packed during which process the small amount of inside air is expelled. Vacuum packing with flexible pouches is comparatively simple and it has the additional advantage of reducing the size and increasing the strength of the pack.

Once they have been opened, flexible pouches cannot be resealed as satisfactorily as cylindrical metal cans or

stoppered plastic flasks. Nevertheless, the contents can be prevented from escaping, and a certain amount of water from entering, by means of a reclosure strip. This consists of a short length of narrow paper ribbon containing a single length of soft wire. The opened edges of the pouch are folded round the strip, the ends of which are then bent back.

INTERMEDIATE CONTAINERS

If the ration components have laminated pouches or some similar type of container as their immediate containers, it would be necessary to pack them into an intermediate container. In most instances, this would consist of a rectangular metal can but it may consist of a rectangular bag made from reinforced kraft paper laminated with bitumen, or from some similar waterproof material.

A rectangular metal can made from standard gauge tinplate is usually preferred as tinplate is one of the few packaging materials that is completely resistant to rodent and insect penetration. The can may be one of two types, the hand-made type with square vertical corners or the machine-made with rounded corners. Although the former has a space advantage in the packaging of rectangular immediate containers, it is expensive and not usually available in large quantities. Difficulty may also be experienced in providing a suitable lid. Hence the machine-made can is usually preferred but care should be taken to keep the diameter of the rounded vertical corners as small as possible.

The intermediate can may be provided with a press-in type lid, spot soldered to prevent it from being jarred out during transport and handling, or the can may be scored and provided with a two-finger wire handle enabling a panel or strip to be torn out. If the can is to be such that it can have secondary uses, the press-in type lid is probably the better as it enables the can to be reclosed, making it useful

for the storage of water and other goods. The cans may also be used as cooking utensils and for the construction of stoves. A number of cans joined together can be used as a raft. If the top and bottom of a can is removed, the can cut down one corner, and the sides opened out, a catchment for rain is provided.

All cans should be lacquered or painted externally. It would also be an advantage to have the cans marked with the name of the contents, food manufacturer's name and packing date. If two or more intermediate containers are packed in the one ultimate container, it may be considered desirable to place a parting sheet of solid fibreboard between them to prevent rubbing and to give increased rigidity. Corrugated fibreboard is not satisfactory.

When the immediate containers consist of metal cans, the intermediate container may be dispensed with, but in this case each can should be marked in the same way as an intermediate container. The cans are usually separated by a fibreboard parting sheet between each layer. Sometimes they may be prevented from rubbing, and held more firmly in place, by means of straw, paper or some similar packing material.

Frequently, an inner sleeve of solid, or occasionally corrugated, fibreboard is placed in immediate contact with the ultimate container, to give the rations added protection. Although it is shown in the illustration (facing p. 55), this is not often necessary and increases both weight and cost.

ULTIMATE CONTAINERS

Ultimate containers are now made almost exclusively from fibreboard whereas they once consisted largely of wooden boxes.

For the commercial market, most processed foods are packed in ultimate containers consisting of regular slotted fibreboard cartons in which the outer flaps meet and the inner and outer flaps are of the same length. The cartons

are sometimes made of solid fibreboard although considerable use is also made of corrugated board. They are seldom provided with an outer sleeve, but the flaps are fastened down with an adhesive and the cartons may be bound with wire or metal straps. The latter are usually preferred as they do not cut into the carton.

If kept dry, these cartons withstand a reasonable amount of transport and handling, and they may be used for delivering survival rations to depots where they are to be repacked in special containers, such as ejector seats of aircraft or lifeboat lockers. They are not suitable, however, when the survival rations have to remain in their original ultimate containers until such time as they are required for an emergency.

For this purpose, a much stronger and more robust ultimate container is required and it should be made of water-resistant material. Although a variety of ultimate containers are at present in use, the most satisfactory appears to be a solid fibreboard slotted box with an outer sleeve that is held in place by two parallel metal bands or fibreglass ribbons encircling the entire carton. Fibreglass is preferred as it does not rust. The box is designed so that the outer flaps meet and the inner and outer flaps are of the same length. The sleeve has an opening equal to the external length of the box by the external height.

The material of which the box and sleeve are made should be a solid high wet-strength board. The staples or stitches used for fastening the box and sleeve should be made of stainless steel or some other rustproof material, and the adhesive used for sealing the flaps should be waterproof. The markings on the outsides of the boxes should also be done with a waterproof marking material and provide the information suggested earlier. There are several solid high wet-strength boards available and they include monoplys and laminates.

The monoplys are probably the most satisfactory because

they are completely water resistant whereas the laminates may absorb water along their cut edges and on their surfaces to the depth of the first layer of paper. This means that if they are continually wet for any length of time, and then handled, the laminated layers tend to separate at the edges, and parts of the surface layer and any marks thereon may be rubbed off, exposing the under layer of bitumen or other bonding materials. The difficulty can be overcome by coating the finished carton with a waterproof varnish but this adds to the cost.

To reduce costs without sacrificing necessary strength and protection, diagonally slotted boxes have been designed which require only two-thirds the quantity of fibreboard needed for regular slotted boxes and sleeves.[1] By placing the slots diagonally, a double thickness of the board is obtained at the horizontal end score lines without the use of a sleeve, and tests have shown that the design is most satisfactory when these reinforcing flaps are placed on the inside rather than the outside of the container. It is claimed that diagonally slotted boxes without sleeves have a mechanical strength equal to that of regular slotted boxes with sleeves.

The ultimate container has many secondary uses. It may be used for holding or carrying other goods, or a number may be joined together to form a raft for use in smooth waters. If they have been carefully opened and the stitches or staples removed, the boxes and sleeves provide a considerable area of waterproof material that can be used by survivors for constructing a catchment for collecting rain water, or for building a very serviceable shelter.

For ease of handling and stacking, it is important that the base of the ultimate containers be rectangular rather than square and that they fit on to standard pallets with no waste space on the pallet and no more than the permissible overhang.

[1] 'Experimental Diagonally Slotted Boxes', *Activities Report*, 7, 8 (1955).

SPECIAL CONTAINERS

Exposure to pressures that exist at altitudes of about 25,000 feet cause the end panels of metal cans to buckle and, upon descent to ground level, they do not quite return to their original configuration. Repeated ascents and descents, with the accompanying flexing of the end panels, eventually cause the tinplate to fracture and subsequently leak. In addition, normal manufacturing processes do not provide a seal that will resist pressures at altitudes higher than about 18,000 feet.

Such difficulties can be overcome by packing in a special container consisting of a carton-bag-carton combination. The food is first packed in an inner carton to prevent any sharp edges from rubbing against the bag. The inner carton is then placed in an intermediate bag made from a laminate of plastic to foil to plastic to cloth. The sealed bag is then placed in a telescopic type outer carton. The unit forms a special type of container unnecessarily elaborate for the usual multi-purpose ration.

Other special containers have been devised to meet various requirements but they share the disadvantage of being unnecessarily elaborate and too expensive.

Additional Reading

For those seeking additional information on survival at sea, three publications are recommended for further reading. They contain useful information about food, particularly water, and the first publication has an extensive bibliography. They are *Shipwreck-Survivors.* A Medical Study, by M. Critchley (J. and A. Churchill Ltd, London, 1943); *The Hazards to Men in Ships Lost at Sea, 1940-44,* by R. A. McCance, C. C. Ungley, J. W. L. Crosfill and E. M. Widdowson (Her Majesty's Stationery Office, London, 1956); *Survival at Sea—Inflatable Liferafts,* by N. F. Keene (The Maritime Press Ltd, Wokingham, England, 1957).

Both during and after World War II, pamphlets containing advice to survivors on land were issued in several countries. Food, especially water, was one subject almost invariably discussed. Many of these publications are no longer available for distribution but they may be consulted in the libraries of some government departments. Two British pamphlets giving information for survival on land are *Desert Survival* (Air Ministry Pamphlet 225, London, 1952); *Jungle Survival* (Air Ministry Pamphlet 214, London, 1950); and there is also the United States publication *Army Air Forces Survival* (AAF Manual 64-0-1, Washington, 1945). These pamphlets could be of especial value in preparing instruction sheets to accompany food and equipment for survival under a particular set of conditions.

A few scientific papers have been published recently on water requirements and other matters, but they would be of little interest to the average layman. The general conclusions believed to be of practical value have been incorporated in this book together with appropriate references.

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